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Forthcoming Events.

JANUARY 30.

Institute of British Foundrymen (Sheffield and District Branch):—Annual dinner, at Sheffield.

North-East Coast Institution of Engineers and Shipbuilders (Middlesbrough Branch):—General meeting at Middlesbrough. "Shipyard Pneumatic Plant and Pneumatic Riveting." Paper by F. W. Verrill.

JANUARY 31.

Mining Institute of Scotland:—Annual dinner at Glasgow.

Institute of British Foundrymen (Birmingham Branch):—Joint meeting with Staffs. Iron and Steel Institute, at Birmingham. "Continuous Rolling of Steel." Paper by L. D. Whitehead.

Institute of British Foundrymen (Newcastle-on-Tyne Branch):—Ordinary meeting, at Newcastle. "The Structural Composition of Cast Iron." Paper by A. Logan.

Institute of British Foundrymen:—Joint meeting with West Yorkshire Metallurgical Society, at Bradford. "Use of Scrap Metals." Paper by G. Leggard.

Institute of British Foundrymen (Wales and Monmouth Branch):—Ordinary meeting, at Swansea. "Different Methods of Making Steel Castings." Paper by V. C. Faulkner, M.I.M.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

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Welsh Engineers' and Founders' Association.

Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

Inroads and New Fields.

As individuals and firms, either openly or surreptitiously, note every forward or retrograde step made by their competitors, in order that they may be in a better position to realise and utilise their own potentialities, there is every reason to believe that if the foundry industry would take cognisance of the development and progress of competitive trades they could profit thereby. Generally speaking, the competitors to cast iron have a good number of excellent talking points. For instance, drop stampings and drop forgings give a salesman nearly all the material he requires to sell his goods against, say, malleable cast iron or mild steel castings. But according to Mr. J. B. Hoblyn, in an article to the "Drop Forger," he has received drop forgings made from 3.0 per cent. nickel steel in place of 14 per cent. chrome steel; dead mild carbon steel in place of 1 per cent. chrome, 0.40 carbon steel; case hardening nickel steel instead of 0.40 per cent. carbon steel, 0.40 per cent. carbon steel instead of nickel chrome, and medium carbon 3.0 per cent. nickel steel in place of case hardening nickel steel. The indictment is continued, and the whole makes a fine opening for the smart castings salesman to sow the seeds of doubt as to the efficiency of forgings and stampings in the minds of buyers, and perhaps, if not probably, when there has been a distinctly glaring case of negligence on the part of the drop forger, he may be able to introduce, or reintroduce, his product.

Efforts are being made to induce founders to standardise patterns, with which we are in entire sympathy, but the ease of altering many types of patterns, as against the high cost of modifying dies, is always a good talking point.

Whilst drop forgings are competing with foundry products, no real effort is being made by the foundry trade to compete with other industries. As we pointed out in a recent issue, it does not exist as one concrete industry, but as a department of many other industries. Thus it is impossible for it to make a unified effort to create new demands. The best field for castings appears to be the replacement of wood, brick and stone, telegraph poles, sleepers, house construction, railway carriage doors. The majority of these require a national committee, though perhaps the National Light Castings Association could tackle some of them. The battle for cast iron houses is being waged by two Yorkshire foundries, but surely if the demand can be met it should not be left to two firms to attempt to meet what would be, if successful, an enormous demand.

Cast iron is the natural successor to wood, bricks and stone, and not steel. Yet steel is the material which national propaganda is forcing on the British public. The question of telegraph poles has been cited by Mr. R. O. Patterson, the President of the Institute of British Foundrymen, who stated that he believed they could economically replace imported timber. Steel sleepers are used largely on the Continent, but cast iron, if made on the best quantity production lines, appears to us that it could be made competitive. Railway wagon sides, if made in good quality cast iron, could be made sufficiently thin and yet strong to replace wood without giving an excess weight. The replacement of railway carriage doors is an aluminium alloy job, and some progress has been made in Great Britain for the Australian systems. The chilled car wheel is an important section of the American foundry industry, which is practically non-existent here. It, too, requires a national effort to introduce it. Surely they are sufficiently strong for railway contractors' wagons.

The foundry industry can never hope to break new ground until a truly representative commercial body has been brought in existence. This cannot happen until manufacturers having foundry departments realise that they are foundry owners.

West Yorkshire Metallurgical Society's Annual Dinner.

The second annual dinner of the West Yorkshire Metallurgical Society was held at Huddersfield on January 17. The president, Mr. H. F. Coggan, was in the chair.

After the loyal toasts had been honoured, PROFESSOR C. H. DESCH, of Sheffield University, proposed that of "The West Yorkshire Metallurgical Society." He said everyone was now familiar with wireless—so familiar that it had become almost a nuisance. Now they found the wireless valve actually used for conveying the electrical current required for smelting purposes. Within a few months there would exist in Sheffield small experimental furnaces thus worked by wireless valves. It was an application of which one would not have dreamed two years ago. Not very long ago the electron was a hypothetical idea existing in the minds of a few physicists, and looked on as the product of abstract speculation, but of no importance to the practical man. Now one could go into places where large valves might be seen conveying as much as twenty horse-power electrical energy across otherwise empty space on a stream of electrons.

With all these facts in their minds they realised how essential it was for all who wished to keep pace with the progress in industry to keep pace with the progress of science. All those interested in the scientific side of metallurgy rejoiced to see the activities of societies where metallurgists could discuss their problems and hear of the progress being made. He had great pleasure in proposing the toast of the Society, and wished it every success in its future sessions. (Applause.)

For the Benefit of Industry.

THE PRESIDENT responded to the toast, saying that metallurgists were engaged in research work for the benefit of industry. Although the knowledge they gained might not bear immediate fruit, yet it undoubtedly would benefit the next generation. He hoped that employers would encourage metallurgists to join such societies as theirs, and he would like to ask the presidents of other societies to associate with them, to hold, at some time, a National Metallurgical Convention.

The Advancement of Knowledge.

MR. ROBERT ARMITAGE, of Farnley Hall, Leeds, proposed the toast of "Our Guests and Kindred Associations." He said that thirty or forty years ago there was very little metallurgical work and very little metallurgical knowledge, but, thanks largely to Sheffield University, people to-day knew a great deal more about metals than their ancestors did. They now knew a great deal about the behaviour of metals. The study of metals, especially of iron and steel, had gone ahead far more than most people realised. The engineer must learn to consult the metallurgist and the metallurgist must be prepared to give the engineer intelligent reasons for his beliefs. If there was anything wrong with a piece of metal there was a reason for it, and he did not think the steelmakers had anything to fear in giving customers reasoned explanations when anything went wrong.

MR. L. BALDWIN, of the Bradford Engineering Societies, responded, and said he agreed that there ought to be greater companionship between metallurgists and engineers.

MR. H. SUMMERSGILL, of Bradford, the president of the West Riding Branch of the Institute of British Foundrymen, also responded.

In proposing the toast of "The Profession of Metallurgy," Mr. G. G. S. GRUNDY, of Leeds, said that the old "rule of thumb" had gone, and it was now recognised that metallurgists and chemists were absolutely necessary.

MR. T. E. HULL, of Huddersfield, in reply, said that for far too long had the metallurgist lived an isolated life in the laboratory. It was true they had in their outlook and ideals a co-operative spirit to bring them into closer contact with other branches of the industry. He would suggest that metallurgists should be encouraged to take more places on the various boards directing the engineering and metallurgical industries of the land.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Plastic Wood.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—A Berlin message widely quoted in the British Press states that the "latest invention," apparently in Germany, is a plastic wood which is sold in tin boxes. It is said that this plastic wood can be moulded into any shape when it sets firmly, and can then be carved and polished in the manner of ordinary wood. It is impervious to water when set, and is not influenced either by heat or cold.

These statements appear so accurately to describe the qualities of plastic wood as prepared by one of the constituent companies of Nobel Industries that there can be no doubt they refer to the British product. In common fairness, therefore, to British scientists and British laboratories, we feel it our duty to state the true position.

Plastic wood has been made for some time past at our factory at Stowmarket. It has attracted a great deal of attention on the Continent, and that, we believe, is the explanation of the fact that the story of a purely British invention should have, paradoxically enough, inspired a news message from Berlin.—Yours, etc.,

E. C. STAMP.
Director and Secretary,
Nobel Industries, Limited.

Nobel House,
London, S.W.1.
January 17, 1925.

Smoke Abatement.

A special International Smoke Abatement Exhibition is to be held in the autumn of next year at Bingley Hall, Birmingham, under the auspices of the Smoke Abatement League of Great Britain, 33, Blackfriars Street, Manchester. It has also been decided that during the exhibition a series of important conferences will take place, covering every aspect of smoke abatement and remedial measures in periods of fog.

The Iron and Steel Institute.

The annual meeting of the Institute will take place on Thursday and Friday, May 7 and 8, at the Institution of Civil Engineers, Great George Street, London, S.W.1, by kind permission of their Council. The annual dinner will be held on the evening of Thursday, May 7, at the Hotel Cecil, Strand, W.C. The autumn meeting will be held in Birmingham, on Wednesday, Thursday and Friday, September 9, 10 and 11.

The Refractories Association.

At a meeting of the Refractories Association, held January 23, at Sheffield, Mr. Mark. C. Robson, of the firm of Davies & Robson, Railway Traffic Experts, of Newcastle-on-Tyne, gave an address on the subject of Railway Rates and Charges.

An old foundry in St. John's Street, Huntingdon, is reported to have been acquired by a Canadian agricultural implement firm for use as an assembling works and distributing centre for their products.

Extruded Metal: A Dip into Pandora's Box.*

(*For illustrations see page 95 et seq.*)

By Wesley Lambert.

A brief description by the Author of the extrusion process preceded the reading of the Paper.

The author, during the period of the late war, was called upon to supervise the extrusion of yellow metal rod from a new plant erected to help meet the war-time demand of the Government for this commodity. The press was supplied and erected by a British firm having some experience in the manufacture of presses for the extrusion of metals. No information was forthcoming from the makers of the press as to the actual details of the operations involved in the extrusion of yellow-metals; the principal of the firm frankly admitted that although he had previously supplied a number of presses during a period of some years, neither he nor any member of his staff had been permitted to witness the actual extrusion of a metal rod. This fact is quoted merely to indicate that in pre-war times the extrusion of metals was considered to be a more or less secret operation to be conserved among the few British firms conducting this process. At this date the author's own experience of metal extrusion did not extend much beyond lead-squirting, and so far as the extrusion of yellow-metal is concerned his knowledge was practically nil.

All-fools' day was to have been the birthday of the first rod to be extruded from the new plant, but as a little knowledge is said to be dangerous, and for reasons which may well be imagined, the birthday of the first rod was anticipated and the first billet was extruded on the last day of March. Upon critical examination, the first-born rod was found to be a fine healthy stripling 1¼ in. dia., some 50 ft. in length, and weighing 4½ lb. to the foot.

"There's nothing in it!" "It's as easy as making sausages!" These were the sort of gleeful comments regarding the process made by those privileged members of the staff who witnessed the "birth" of this length of extruded yellow-metal rod.

1916-1917 saw a large number of extrusion presses erected throughout the country. The Yellow-Metal Rod Department of the Ministry of Munitions was desirous of securing a weekly supply of not less than 2,000 tons of rod, the major portion of which was intended for the manufacture of fuze bodies and parts. In some instances the billets to be extruded were supplied to the rod manufacturers from outside sources, in which case they had merely to be reheated and extruded. In the case of those firms receiving cropped billets, the amount of discard left in the container was very small; the discard in the case of uncropped billets was left to the discretion of the rod manufacturers. If a billet failed to extrude, or the extruded rod was defective, the blame, if any, was naturally ascribed to the billet, and any such metal was returned as defective metal; the onus passing to the billet manufacturer, who, naturally, in turn, blamed the firm conducting the extrusion. This more or less happy method of shifting the responsibility for the defective material, could not appertain, however, in the works of those firms who had the dual responsibility of both manufacturing and extruding their own metal. The author, being on the staff of the latter type, had to seek the why and wherefore of any failures, and also to discover the necessary remedial measures to obviate the loss incurred by producing defective rod.

FIG. 1.—REAR VIEW OF EXTRUSION PRESS.

In this paper the author considers it is unnecessary to describe at length the process of extrusion, but to refer anyone unacquainted with the plant and the methods employed, to such literature as has already been published on the subject. The general appearance, however, is illustrated in Figs. 1 and 2.

Without doubt, the most prevalent and serious defect in much of the war-time extruded rod manufactured both in this country and America

* A Paper read before the Newcastle Section of the Institute of Metals and the London branch of the Institute of British Foundrymen. The Author is manager of the metallurgical department of Messrs. J. Stone & Company, Limited, Deptford.

took the form of "coring," a defect which somewhat inadvisedly has been designated as "*the extrusion defect*," a designation which has placed the whole output of extrusion under suspicion, to the annoyance of the extruded metal manufacturers. The old adage about giving a dog a bad name holds good, equally so, when applied to a manufactured product.

Incidentally, it may be mentioned that "coring" in metal rod is neither wholly confined to rod manufactured by the extrusion process nor to any one type of metal, and the author has in his possession more than one example of a similar defect discovered in rod produced at the rolling mills. The factors which contribute to the formation of this particular type of defect have been investigated by a considerable number of workers, from among both those engaged in the actual process of extrusion and independent investigators. Opinions have been expressed, certain conclusions have been arrived at, and remedial measures have been suggested. Some of the findings and conclusions which have been published are reviewed below :—

Views as to Origin of "Extrusion Defect."

A. E. and P. A. Tucker (1) by a process of elimination have arrived at the conclusion that piping ("coring") was principally a mechanical issue of extrusion, and was chiefly due to the entrance of part of the shell or skin into the plastic metal under the action of the ram. Also segregation in billets undoubtedly resulted in piped bars. H. H. Hayes (2) has put forward the theory that it was probably the production of amorphous material by the friction of the billet in the container, which renders the skin of such hardness as actually to penetrate the comparatively softer core, and consequently it would appear in the pipe (core) as though the skin of the metal had been turned in under the surface. Johnson (3) has called attention to the difference in the mechanism of crystallisation between the outer shell and the inner core of the cast billet, and has suggested that the defect ("coring") may possibly be caused by the occurrence of gas pockets between the chill crystals round the skin and the equi-axed crystals in the interior. Genders (4) has agreed with the conclusion of A. E. and P. A. Tucker cited above, but has not supported suggestions that segregation and the crystalline structure of the billet are factors affecting the occurrence of the defect ("coring.") Redding (5) has said that, speaking generally, he would not describe the loose centres in extruded bars which he had examined as being dirty; in most cases they were just covered with a thin film of oxide. Rosenhain (6) has stated that he did not think in the majority of cases the central defect in extruded bars was due to the external skin. The oxidised back surface, however, flowed down and produced a defect of that kind. He believed defects in the ingot to be an important cause. Moore (7) has given a considered opinion that Genders had proved that what was described as the "extrusion defect" was entirely due to different causes other than defects in the ingot. R. H. Greaves (8) has stated that external defects on the billet became internal defects in the rod. P. A. Tucker (9) has evidenced that he had seen many "badly" piped (cored) bars extruded when complete "skulls" of billets, whose surface had been marked off, were left in the container. Genders (10) has vetoed the suggestion that ingot defects might be responsible for the "extrusion defect." He could not at present support the theory of the formation of fissures by critical local conditions in the billet, but has admitted (11) that if the ram is small and misses the skin of the billet, the defect ("coring") is avoided.

FIG. 2.—SHOWS GENERAL APPEARANCE OF AN EXTRUSION SHOP.

Mawson (12) has written that the rate of extrusion probably plays an important part in the formation of pipes. With too quick extrusion the centre portion of the billet, which cools slower than the outer portion, may move too quickly relative to the outer diameter and cause an elongated pipe (core) to form. He has also stated that a pipe (core) has always an oxidised surface, which once formed will never weld under either pressure or temperature to form solid metal. Genders (13) cites American experiments which confirmed his previously expressed opinion that speed of extrusion had no effect on the formation of piping. Tucker (14) says the piped end of billet should be cropped. If not cropped, it should be placed towards the die in the press container. Mawson (15) says, to reduce piping as much as possible, the billets should be placed in the container with the end which is poured last pointing towards the ram. Tucker (16) insists that the die must be made and kept hot, or it might chill the surface of the rods to such an extent as to convert them into veritable tubes through which the more plastic metal could flow.

From the foregoing, it is obvious that in these published statements there is an excuse for anyone thinking there is a want of agreement as to the cause of the "coring" in extruded rod. One may even go farther, and say that in one or two instances the statements appear to be quite contradictory. One investigator ascribes the sole cause of the "coring" to be due to the outer skin forming part of the central portion of the extruded rod, and he admits that if the ram is small and misses the skin of the billet, the defect is avoided. Another investigator affirms that he has seen many extruded rods showing the defect, notwithstanding the fact that the skin of the billet was left intact in the container of the extrusion press.

It is the author's intention, firstly, to endeavour to show that internal defects in extruded rod are produced in more ways than one under manufacturing conditions, and, secondly, to cite a few samples of happenings in workshop practice to support the sub-title of this Paper.

To anyone unaccustomed to bringing an analytical mind to bear when watching the conduct of a metallurgical operation, the process of extrusion may possibly appear to be such a simple and easy affair as to call for little technical knowledge and skill. By reason, however, of the deceptive simplicity of the process and a lack, during the period of the war, of a sufficient number of expert technical supervisors, the many unforeseen pitfalls which confronted the inexperienced manufacturer were undoubtedly responsible for much of the war-time defective extruded rod.

Basic Conditions for Success.

To determine the most favourable conditions under which structurally homogeneous yellow-metal rod or shapes to any given specification can be produced by the extrusion process, it is imperative that due consideration should be given to the following points:—The chemical composition of the metal; the method of compounding the charge; the type of furnace to be used; the temperature and time taken in melting the charge; the control of the melting losses; the casting temperature; the material and thickness of the billet mould; the dressing and temperature of the mould; the skimming of the metal; the pouring speed and method of casting and feeding the billet; the interval of time between the filling and the stripping of the mould; whether the billets are to be cropped or used entire; whether to allow the billet to cool out, and subsequently reheat, or to use hot from the billet mould; the temperature to be maintained in the billet reheating furnace; the means to be taken to ensure uniform heating of the billet throughout; the temperature of the press container and also of the ram and the die; the speed of extrusion; the amount of discard; and the rate of cooling of the rod or shape. Other considerations relate to the best design of the die; whether the size and section of the desired rod or shape admits of a multiple die being used; the contraction allowances; the relative diameters of the billet and the bore of the container; and the diameter and shape of the "dummy ram," and the means of ensuring its concentricity with the billet.

With a view of emphasising the importance of full consideration of some of the points above mentioned, it may be as well at this stage to illustrate a few examples of happenings and failures.

Improper Conditions.

Fig. 3 shows the result of an attempt to extrude a billet of "incorrect composition." By "incorrect composition," in this particular instance, it is to be understood that the chemical composition of the metal of the billet from which this specimen was extruded differed from the composition of the normal batch of billets being extruded at that time. At a temperature suitable for a metal of the chemical composition of this specimen, the billet would have extruded, doubtless, in a satisfactory manner. (The spiral effect observable in this specimen is attributable to the presence of a very shallow scratch left on the die by the reamering tool).*

Want of smoothness in the advancement of the hydraulic ram is clearly indicated by the "steps" along the length of the rod. Two other examples, Figs. 4 and 5, are given further to illustrate the jerky character of the movement of the press ram when attempting to extrude metals at incorrect temperatures or of unsuitable composition for the extrusion process. Fig. 6 serves to illustrate an example of "coring," and also incidentally points to a lack of supervision in the compounding of a charge of yellow metal of the 60-40 type. The spelter in this particular case was not properly incorporated in the mass of metal constituting the charge, thereby resulting, on extrusion of the billet, in the production of a length of rod having a cored centre consisting of metal with an wholly alpha micro-structure; the core being contained in a concentric sheath of metal, rich in the alpha-constituent adjacent to the core, but passing gradually through the alpha-plus-beta structure to an all-beta structure on the outside. It is scarcely conceivable that such a specimen as illustrated can be produced other than as a result of improper mixing. Improper mixing of the molten metal forming the billet charge, with consequent zones of metal of different composition in the billet, may therefore yield extruded rod exhibiting a cored defect. (In a contributed article in the issue of the "Metal Industry" of November 19, 1920, the writer states that: "In billets of brass it is necessary that the metal be thoroughly mixed when casting, as otherwise only part of the billet can be extruded, and a big portion of it may be wasted through being too hard.")

Dual Structure as Cause of "Extrusion Defect."

Fig. 7 illustrates the cross section of a yellow metal billet cast in a cast-iron billet mould of the usual thickness employed in works practice. The metal was cast in a warm mould, the temperature of the molten metal being somewhat on the high side. The diameter of the billet was 6¼ in., and the length about 27 in. The weight of metal in a billet of this size is approximately 250 lbs. The fracture is interesting, showing, as it does, a very striking symmetrical outer ring of columnar crystal grains, due to the chill effect of the heavy cast-iron mould on the metal of the billet; normal equi-axed crystal grains make up the centre portion of the billet. In the author's opinion, this dual crystalline structure, as exhibited in the fracture across the billet, is a very important factor in relation to the formation of a cored rod.

Fig. 8, from a photograph, is from a machined section from the same billet cut at right-angles to its long axis. This section was taken with the object of ascertaining whether there was a want of cohesion, or possibly even a wall-space, between the two forms of crystal grains exhibited in the fractured section. The disc was held upright upon the anvil of a steam-hammer and lightly struck upon the edge, with the result shown. That portion of the disc formed of the columnar crystal grains has parted in places from the central portion consisting of the equi-axed crystal grains, and probably had the hammering been continued the whole of the outer ring of metal would have peeled off. The result of this experiment confirmed a previously formed opinion as to the unlikelihood of any considerable cohesion existing between the two forms of crystallisation.

Prolonged Heating and Dual Structure.

Fig. 9 shows a fractured surface through a similar sized billet to that from which the previous specimens were obtained. This fracture is interesting as showing not only a large grain growth due to over-long heating of the billet in the re-heating furnace, but it clearly shows also two further features, firstly, that the outer ring which before re-heating was of columnar crystalline formation has more or less entirely lost its previous very distinctive character, and, secondly, that although considerable growth of grain has taken place in each of the two zones of crystalline formation, there is no trace of either coalescence or boundary migration between the grains of the (pre)-columnar and (pre)-equi-axed small crystalline portions of the billet. Moreover, there is a distinct evidence that the lack of cohesion between the outer ring of the billet and the central portion, as exhibited by the previous specimen, still persists even after the metal has been re-heated at a sufficiently high temperature, and for a sufficiently long

* Although of specially selected steel, a virgin die, when first put into use, yields owing to the heavy pressure exerted on the face of the die, and the bore closes. In the case of circular dies the bore is often opened out at the press by a hand reamer employed with a screw-like motion.

period for the grain growth in both zones to become very pronounced.

Fig. 10 illustrates the polished and etched surface of a full-width longitudinal section through the axis of a normal billet of yellow-metal. The billet was 27 in. long and 6 in. dia., cast in a cast-iron mould of the same design and thickness as that used for casting the billets from which the previous specimens were obtained. The temperature of the molten metal in this instance was normal, namely 50 to 60 degs. Cent. superheat. The billet was top-poured and the liquid contraction of the metal was followed up by the addition of hot metal. The etched surface of this section shows the grain-structure to be small and very uniform. There is no marked outer zone of columnar crystals; little if any indication of severe chilling of the outer portion of the metal is apparent. The billet is free from abnormal "piping," and what little dross is observable is confined practically to the extreme top of the billet. A billet such as is represented by this section may be regarded as normal in extrusion practice, and assuming other conditions, hereinafter mentioned, to prevail, should result in the production of sound rod.

Figs. 11, 12, 12a illustrate a common form of the core-defect in war-time extruded rod, and probably are quite typical of the defect in the rod examined by Redding, (5) described by him as having a loose centre which he would not describe as being dirty; being in most cases just covered with a thin film of oxide. This form of defect has received much patient consideration by the author, and will be referred to later.

Fig. 13, slide 8, shows the transverse fracture of an extruded yellow-metal rod, 2¼ ins. dia., of the 60:40 type, serves as an additional illustration of the core-defect. In this instance, however, the fracture, in addition to exhibiting a more or less loose core in the centre, is seen to be surrounded by metal having a fine granular structure, which in turn is encased in a concentric zone of metal of larger grain growth, which in *its* turn is surrounded by an outer zone of metal with a very small grain.

Fig. 14, slide 9, shows a polished and etched section of the same rod cut from near the fracture shown in Fig. 13, and Fig. 15 illustrates polished and etched transverse section of a rod, 2¼ in. dia., of nearly, but not entirely, homogeneous grain structure.

Fig. 16, slide 10, is from a photograph of a similar polished and etched section to the foregoing, but exhibiting an outer ring of larger grain-growth to that of the central portion of the rod.

Figs. 17 and 18, slides 11 and 12, are from photographs of a further selection of polished and etched transverse sections of yellow-metal rod, of 60:40 type, showing want of homogenity in grain structure.

Fig. 19, slide 13, shows a polished and etched longitudinal section, of full-width, cut from the "discard" of a billet which has been extruded. The length of the discard is 6 ins. The diameter of the rod extruded was 1 in.

Fig. 20, slide 14, presents a similar section, showing the result of the shearing effect during extrusion on the metal of that portion of the billet located in the corner of the die end of the container, whilst Fig. 21 illustrates the remainder of a billet removed from the die end of the container after practically the whole of the billet has been extruded. The loose lamellæ of the metal are worthy of note.

Figs. 22 and 24, slide 15, are from photographs of portions of rods having a more or less thin enveloping sheath of metal. This defect is often occasioned as a result of extruding too great a portion of the metal of the billet. The mechanism of the formation of this defect may readily be understood by reference to Figs. 19 and 20.

Fig. 23 illustrates a detached tubular sheath, discovered as a loose envelope, on a short length of extruded rod. The illustration Fig. 25 is a reproduction of a section, exposing a gas pocket, and cut through the longitudinal axis of a piece of extruded yellow-metal rod. The presence of this somewhat uncommon defect was indicated by a local swelling in the rod immediately after extrusion of the rod.

Two examples of "freaks" are illustrated in Figs. 26 and 27. The former resulted from "improper composition" at the extrusion temperature employed, whilst that on the right (Fig. 27) was occasioned through the die being fouled at one side of the aperture, and thus causing one edge of the strip to ruck.

A Hollow Rod Extrusion Trouble.

Figs. 28 and 29 refer to a failure, which although having little or no bearing on the occurrence of defects in extruded rod, is included as an interesting example of one of the author's early failures when attempting to extrude thick walled tubular rod. A considerable length of the rod extruded on one occasion was quite normal, with the bore truly concentric, but after detaching the rod from the discard of the billet, the severed end of the rod was found to be solid. Upon exploring the length of the rod, the nipple-end of the mandril, over which the major portion of the metal had passed, was found to have become ruptured from the end of the mandril and to be completely embedded in the rod. The steel of which the mandril was made had yielded to the stress to which it had been subjected, and was drawn out to a fine point before rupturing, as shown in Fig. 29.

Fig. 30 shows a conglomerate mass resulting from an attempt to extrude an over-heated billet of yellow-metal, whilst Figs. 31 and 32 illustrate the marked difference in the macro-structure of the metal first extruded compared with that of the last portion of the metal to leave the die.

Figs. 33, 34. Slides 20, 21 and 22. Large crystal grains, from long exposure in the reheating furnace.

Fig. 35. Slide 23 is an extruded rod cracked after drawbench reduction, and showing the effect of overstressing drawn extruded rod. This rod cracked a few hours after being manufactured.

From the foregoing descriptions of the illustrations, it is obvious that the extrusion process is one which requires to be thoroughly understood and to be conducted under expert technical supervision, if commercially sound rod is to be produced.

The fact that the works metallurgist does not rush into print is perhaps only natural, when one remembers that his knowledge is gained in a hard school; a school in which the great lesson to be taken to heart is that in works practice the unexpected may often happen, and that it is unwise to be dogmatical. It is erroneous to assume, however, from the fact that the results of the works-metallurgist's systematic researches are rarely published, that therefore no such work is done, and, equally so, that the author of a "paper" was necessarily the first, or the most qualified, to investigate a works problem. Insufficient credit is allocated to the works-metallurgist, often perhaps by reason of his "publicity department" being too reticent.

Other Causes of Coring Defect.

Reverting to the defect of "coring" in extruded rod, one of the first illustrations reproduced featured one form of the defect which results from bad mixing of the molten metal forming the billet charge from which the rod was extruded. A second form of the defect is the more or less loose core, sometimes described as being of columnar structure, three examples of which have been illustrated. In the author's opinion this type of "coring" is attributable to the extrusion of defective billets; defective only in the sense that the metal has been too severely chilled on the exterior as a result of teeming the metal into cold moulds. Assuming a condition of things to exist, as shown in the earlier illustration, with a lack of cohesion, and, maybe, a wall-space between the outer ring of columnar crystalline formation and the centre portion of equi-axed crystalline structure, it does not require a great deal of imagination to expect to find the rod exhibiting a cored defect when produced by the simultaneous extrusion of a metal from the inner portion of the outside zone, and metal from the central zone, of a billet of the construction shown this evening. If a wall-space exists, the probability is that a loose core will result, and upon fracturing the rod, the surface of the exposed core and the inner wall of the core pocket may be found to be tarnished as a result of contact with the gases which had collected in the wall-space.

In cored rod with the above type of defect,

there may be an entire absence of any material derived from the extreme outside skin of the billet. In this type of defective rod a very pronounced feature of the outer wall of the core is its fluted appearance. Such a core is often described as being of columnar structure. This somewhat distinctive marking of the core is a mechanical effect, attributable to a difference—owing to varying "grain"—in the relative behaviour under compressive stress of the two streams of metal as they converge towards, and pass through the die to form the core and sheath respectively.

A third form of the "core defect" is one resulting from want of uniformity in the temperature throughout the reheated billet. A billet becoming chilled on the outside, as happens when it is transferred from a hot reheating furnace to an insufficiently heated container, or a billet heated too rapidly in the furnace and not soaked through, will more often than not result in defective rod showing a cored defect. The defect in this instance is to be expected, as the heated metal of the inner and outer portions of the billet being of different temperatures will have different viscosities or rates of plastic flow. A cold die, likewise, may be responsible for a more or less pronounced double extrusion.

A fourth form of coring in extruded rod is that arising from a too pronounced "concertina" effect on the wall of the billet, when end pressure is applied, as may happen in the case of billets of relatively small diameter compared with the diameter of the container. Instances have been observed, in which the "accordion pleated" effect has been very marked on billets of the character indicated, and which had been subjected whilst hot to end pressure in the container of the extrusion press, and subsequently withdrawn without proceeding to the stage of actual extrusion. Rod produced from billets of this category, when "cored," may show evidence of the outer skin of the billet having migrated to the centre portion of the extruded rod.

In some cases where there is a considerable difference in the diameter of the billet and the diameter of the press container, the billet may buckle inwards or kink on the top side relatively to the container. The cored defect, in such instances, will be accompanied with oxide, etc. from the outside skin of the billet, and in all probability will be found out of centre in some portion of the defective rod.

The simultaneous extrusion in the form of rod of metal from two somewhat pre-remote positions of a billet, in addition to the formation of the "coring defect," is also responsible for the want of uniformity in the size of the grain throughout the cross section of the rod. This want of uniformity of grain size, as also the variableness in the location of the larger grains is very evident in the examples previously illustrated.

Remedial Measures.

The remedial measures against defects which have been adopted in order to secure the present day supplies of excellent extruded rod may briefly be stated to be as follows:—(1) Close limits in chemical composition for any one class of metal; (2) standardised practice for each class of metal, and strict supervision in the billet foundry; (3) pyrometric control of all thermal operations; (4) the closest agreement practicable between the diameter of the billet to be extruded and the container of the press; (5) the provision of means to ensure the concentricity of the ram with the container, also of the dummy-ram, if one be used; (6) the reduction in the diameter of the ram or dummy-ram to permit of a "skull" or "flashing" being left in the container after the extrusion of the major portion of a billet; such "flashing" to comprise practically the whole of the original skin of the billet; (7) hot container, hot dummy-ram, hot die; (8) a liberal discard of metal; (9) the close inspection of all rod, the inspection to include an examination of fractured ends.

In conclusion, the author—now no longer directly interested in the manufacture of extruded rod—would like to bear testimony to the excellence, both as regards uniformity in quality and freedom from defects, of the many tons of post-war extruded rod which he has personally inspected and tested.

References.

(1) "Metal Industry," March 21, 1919, page 234.
(1a) "Machinery," April 3, 1919, page 30.
(2) "Metal Industry," March 28, 1919, page 247.
(3) "Metal Industry," March 28, 1919, 1919, page 248.
(4) "Journal of Institute of Metals," 1921 (2), page 239
(5) "Journal of Institute of Metals," 1921 (2), page 247
(6) "Journal of Institute of Metals," 1921 (2), page 249.
(7) "Journal of Institute of Metals," 1921 (2), page 252.
(8) "Journal of Institute of Metals," 1921 (2), page 255.
(9) "Journal of Institute of Metals," 1921 (2), page 256.
(10) "Journal of Institute of Metals," 1921 (2), page 257.
(11) "Journal of Institute of Metals," 1921 (2), page 253.
(12) "Metal Industry," March 21, 1919, page 229.
(13) "Journal of Institute of Metals," 1921 (2), page 256.
(14) "Journal of Institute of Metals," 1921 (2), page 457.
(15) "Metal Industry," March 21, 1919, page 229.
(16) "Metal Industry," March 21, 1919, page 233.

Contracts Open.

Bangkok (Siam), May 1.—Steel rails and permanent way accessories, for the Administration of the Royal State Railways of Siam. The Department of Overseas Trade.

Bangkok (Siam), May 15.—Superstructures of steel railway bridges, for the Administration of the Royal State Railways of Siam. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

Deal, February 13.—Supply 15 tons of 5 in. dia., 25 tons of 4 in. dia. and a small quantity of 3 in. and 2 in. dia cast-iron socket pipes, for the Corporation. T. and C. Hawksley, civil engineers, 34, Old Queen Street, Westminster, S.W.1. (Fee, £3 3s., returnable.)

Finland, April 1.—Materials, etc., for the sector sluice and the turbine chambers for the equipment of an hydro electric plant, for the Government Water Power Office in Helsingfors. The Department of Overseas Trade.

Johannesburg, February 11.—The Municipal Council of Johannesburg requires 500 steel tyres for tramcars. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. No. A.X. 1627.)

London, S.W., February 3.—Cast-iron sleeper pots for B.S. 90 lb. B.H. rails, comprising 93,750 cast-iron sleeper pots, right hand, 6,250 do. left hand, broad gauge, total approximate weight equals 5,090 tons, for the Madras and Southern Mahratta Railway Company, Limited. The offices of the Company, 25, Buckingham Palace Road, Westminster, S.W.1. (Fee, £1 1s., non-returnable.)

London, S.W., February 3.—242 pairs wheels and axles, complete with Sandberg sorbitic tyres, for four-wheeled covered and open goods wagons, metre gauge, for the Madras and Southern Mahratta Railway Company, Limited. The offices of the Company, 25, Buckingham Palace Road, Westminster, S.W.1. (Fee, £1 1s., non-returnable.)

Youghal.—About seven miles of 7-in. cast-iron water main, for the U.D.C. Mr. B. O'Flynn, engineer, Trinity Chambers, South Mall, Cork. (Fee, £2 2s., returnable.)

Port Elizabeth, South Africa, February 13. — The Municipality of the City of Port Elizabeth requires sewage pumping or ejecting plant "Area 3A (Section 1)." The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Fee, £2 2s., returnable.)

South Bank, near Middlesbrough, February 5.—Supply of pumping machinery and erection thereof at their pumping station in Normanby Road, South Bank, near Middlesbrough, for Tees Valley Water Board. Mr. T. S. Calvert, clerk, Municipal Buildings, Middlesbrough, or J. Mansergh & Sons, 5, Victoria Street, Westminster, London, S.W.1. (Deposit of £2, returnable.)

Company News.

Greenwood & Batley, Limited.—Interim dividend, 2½ per cent.

Warner & Company, Limited.—Interim dividend, 2½ per cent. on ordinary shares.

Enfield Cable Works, Limited.—Interim dividend, 5 per cent., less tax, on ordinary.

Beyer, Peacock & Company, Limited.—Final dividend on five and a-half per cent. preference shares for year 1924 passed.

Elliott's Metal Company, Limited.—Interim dividends, 2½ per cent. on preference shares for six months and 1s. per share on ordinary shares, both less tax.

Steel Developments, Limited.—Profit, £7,869; brought forward, £740; final dividend, 3 per cent. per annum, making 5½ per cent. for year, and bonus 2 per cent., free of tax; carry forward, £2,692.

Small Work Moulding in Green and Dry Sand.*

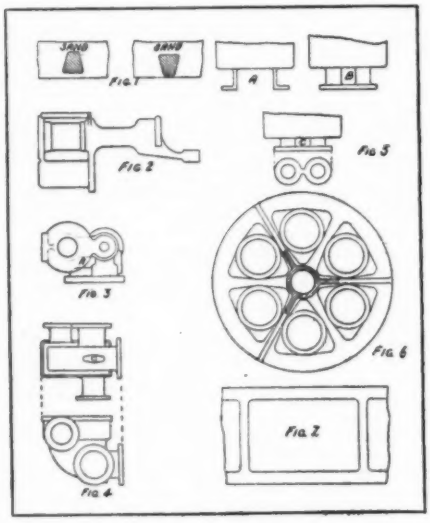
By J. D. Nicholson, M.I.Brit.F.

INTRODUCTION.

When reading literature or hearing Papers relating to sand moulding, a certain amount of latitude must be allowed because there are, in foundries and foundry work, numerous instances continually arising which help the various operations of moulding. The object of my Paper is to emphasise the important features in green and dry sand moulding, which must be adhered to, to produce reliable moulds and sound castings—together with some practical hints.

The illustrations are simple with a view to showing effectively the principles desired, so that they may be carried out under more exacting circumstances. The Paper deals with small work, such as would come under the term jobbing castings, and the base sand used throughout is Erith yellow loam. For green sand work it is used in the new or green state, whilst for dry sand work it passes through a process of milling.

Moulds of either sand may be made successfully in many cases by unskilled labour, yet one is often confronted with numerous types of patterns, the making of tackle for and the moulding of which calls for the highest skill of the foundrymen. The continued advance in the many branches of engineering tends to various, and usually intricate, additions to patterns.



The Moulder.

A moulder employed upon a large mould may be so engaged for several days, but that is not the case with the small-work moulder, who is required to produce several moulds of different designs every cast, both in green and dry sand.

Each mould claiming separate attention and foresight, method of moulding, parts of pattern to be loosened, type of box available, position of runner and risers, also care of machined parts.

Cleanliness and individuality are qualities which should be acquired by every moulder. A lack of mental calmness has caused many a day's work to fail to reach expectations.

A moulder regularly engaged upon one type or section of mould knows its individual peculiarities, yet a person thus employed is too near standardisation which, although it may be necessary, is not good for producing efficient craftsmen.

General Moulding.

Good facilities for moulding should be maintained. These will not only benefit the employer, but will raise the spirit of the foundrymen in what is universally considered as a dull, rough occupation. By facilities is meant, abundance of old sand, good condition of boxes, and quantity of tackle, such as loose box bars, lifters, grates and loose irons. Whilst turnover methods are preferable, yet occasions arise when floor-moulding must be done.

Jobbing work causes constant handling of boxes and those with stove-dried moulds receive severe handling when removing their castings. Foundries making their own boxes might give due consideration to box thickness rather than strengthening pieces.

A useful item may be to have several sizes of box parts with one standard depth. One would then decide instantly the number of parts any mould would require. Middle parts being without bars, yet possessing holes for loose bars when required, which holes also encourage mould drying, venting and vent passages.

Top and bottom parts are preferable with straight bars cast in. Bottom-part bars, cast less deep, allow the box to be used for a top part if necessary, thereby removing the inconvenience of a flat-bottomed drag. Lugs cast upon all boxes would prove convenient. For hand-work, numerous makes of light, strong boxes are available.

Wood for box bars is permissible with green sand work, but discretion must be used for its use in dry-sand. With repetition work or regular castings, boxes may have their bars made to eliminate the use of lifting tackle. Lifters should correspond with the depth of boxes frequently in use, and of the hanging variety. If a lifter is not hanging over a box bar, it is dangerous to allow it to protrude above the sand. A moulding box 26 in. sq., 12 in. deep, should hold in with dry sand without any definite tackle, except a lifter in a protruding piece of mould.

This size is reduced when using green sand to about 18 in. sq. Above these two dimensions grates wired up may be used to make sure of a hold-in. Grates are broken to suit the shape of the pattern. With dry sand, straight irons, wired-up, may be used as an alternative, with the addition of lifters as the holding—in effect with dry sand bears no comparison to green. Several patterns require a special grate cast, which should be provided in good time previous to commencing the mould.

Deep lifts must have their grates stayed to the top box to prevent any falling away when turning over. It will have been noticed that grates have a narrow side and a broad side (Fig. 1). It is preferable with prominent pieces of mould to use grates having the narrow side down. This allows the sand to bind entirely round the grate. Otherwise the sand underneath the flat side has nothing to hold it save the clay-water. The grate, being tapped down makes this piece of sand hard, and is also overburdened with clay. When drying in the stove, the heat encourages this piece of sand to leave the grate and often does so when molten iron reaches it.

In a green sand mould it is well-known that liquid iron and excessive clay matter do not agree. Both cases result in what is termed scabbing. Sloping or recessed joints may be covered with wet brown paper or sea-sand. Both give good partings. The former being desirable when accuracy or absence of fin is essential. Pieces of patterns which give a very straight lift may have brown paper placed against the side to help a good lift.

The ramming of moulds should be done in such a manner as to ensure soundness being obtained. Hard-rammed moulds resist the exit of gases and generated steam, whilst soft parts produce swellings upon the casting. Sound ramming, providing the pattern is good, will give good lifts with top and bottom parts. It facilitates finishing and makes the mould more reliable.

To overcome ferro-static pressure, increasing as depth of mould increases, one must increase ramming pressure accordingly. The effect of pressure should also be borne in mind when making femmer cores, and also when boxes are being clamped together previous to turning over in order to cast "end-up."

The handiness of oil-sand cores lends itself favourably to coring out awkward parts of a pattern as frequently presented in modern designs.

* A Paper read before the Sheffield Branch of the Institute of British Foundrymen, Dr. C. H. Desch, F.R.S., presiding.

Nevertheless, outstanding or protruding pieces of mould well surrounded with metal are often met with. They should be treated similarly to a core when ramming up the mould either by inserting a row of fine ashes, or, in a dried mould, a piece of wax vent string, thus ensuring a ready exit for accruing steam and gases.

Dry Sand Moulding.

Whatever facilities are used for drying dry-sand moulds, they must be efficient. The majority of faulty castings may be put down to damp moulds. Everything possible should be undertaken during moulding which will encourage the drying of the mould, and also hasten the exit of generated steam and gases formed during filling the mould.

The following may be noted as in favour of and detrimental to a dry-sand mould:—(1) Mixing old sand by hand is laborious and sometimes the mixture receives too much water; (2) too hard ramming retards drying. The grains of sand being too compact affect the porosity, thereby reducing the escape of gases arising from the metal and sand, and perhaps causing them to remain in the iron; (3) narrow places, webs or brackets may have a row of fine ashes or a wax vent string; (4) the free use of a $\frac{3}{8}$ in. vent wire upon bottom and top parts previous to turning over. This facilitates the exit of steam when in the stove and during casting. A similar method may be employed with large brackets between flanges, by using a runner stick or tube about two inches from the mould face and removing it when finished ramming, and (5) excessive application of water when finishing will show cracks on the mould face on its return from the stove.

Scabbing and buckling usually arise from steam forcing the sand into the iron. A scab is rough through sand washing away when the iron reaches it. A buckle happens some time after the iron has passed the part, and is caused by generated steam in the sand having no escape except through the mould face which it forces into the iron to varying depths.

The accompanying diagrams are included for the purpose of demonstrating the foregoing by specific cases:—Fig. 2, for example, is a front elevation of a reversing engine cylinder body, whilst Fig. 3 shows an end view, exhibiting a difficult piece of sand marked A, in which it is preferable to insert a wax vent. Fig. 4 shows a discharge chest with two flanges moulded in the bottom; and in Fig. 5 three views of the bottom parts of valves are shown:—A illustrates a valve with two feet, which are, at times, cored out. A row of ashes between them would benefit the bottom face of the mould; B may be treated in the same manner, whilst C, being very narrow—about 2 in. only—the inserting of a wax vent would have a beneficial effect. Of course, irons are embedded in this piece, care being taken they do not spring.

The last four illustrations serve to show how the iron, reaching the bottom flanges, first causes steam and gases to rise to the mould face, resulting in scabbing or buckling if not counteracted. This fault is susceptible in all flat-bottomed valves and chests. In all cases the steam generated must have an outlet downwards or at the box edge.

Referring to views B and C, loam cakes may be used to form the bottom edge of the flange instead of making a joint and parting. The fact must not be overlooked, however, if provision be made for separating boxes when stoving, the mould will receive a more effective drying. The ramming of top parts is often commenced by smearing the joint with loam and bedding grates, etc., upon it, to provide for a sound joint with the top part, yet it may be avoided when stove-drying.

A handy operation is to add some new sand to wet loam and mix with the hands until a little stiff. This may be applied to accurate facing pieces, pockets, joint brackets and prominent pieces on patterns. A good sound draw with the pattern will be received. These places should be first dampened and dusted with parting sand as in coremaking.

Fig. 6 shows where it may be used upon a head valve with its numerous thin facings. The same operation is desirable with places similar to the bottom flange of a water box shown in Fig. 7. This is about 14 in. deep and floor-moulded. Having removed the screws from the bottom flange, a little parting sand may be sprinkled at the inner edge of the flange. Removing this during finishing with the edge of a trowel preparatory to their withdrawal will facilitate their removal. No fear need be entertained with respect to pieces of mould falling when withdrawing the flange.

Narrow facing strips as found upon flanges which are awkward to blackwash will be skinned satisfactorily if a little coal dust or dry blacking be added to the sand at these parts.

Green-Sand Moulding.

Moulding with green-sand is the branch of founding which requires the utmost skill of the moulder. A good green-sand moulder is a valuable asset, and one who will readily adapt himself to the circumstances required to be adopted with any quality of moulding sand.

It is remarkable the difference in results obtained from various moulders, clearly showing that, although all are seemingly carrying out the self-same operations, there is a difference somewhere which acts for or against the casting.

With many classes of moulding little respect need be taken of the condition of the old sand, nevertheless many types of moulds require the sand to be in a suitable condition. Green sand receives much burnt core-sands whilst removing castings from boxes.

Where any fair amount of green-sand work is carried out, although several things may be in the way as regards possessing any satisfactory plant for cleansing, renewing and mixing old sand, such plant would provide a sand uniform in quality and dampness, besides saving considerable skilled time and energy.

The success of a suitable installation may be compared to the simple operation of riddling sand. If one were to pass a quantity of sand through a half-inch riddle, it will be seen less water is necessary to bring it to working condition as compared to mixing with a shovel, the reason being that damp clots are broken up and evenly distributed among the mass.

Without efficient means of mixing backing sand the risk is taken of wet clots coming too near the facing. This is possible, for when filling in around a pattern the shovel is tilted towards the pattern, the heavy damp pieces falling against the facing.

The quality of the facing sand is the main feature in green-sand work. The mixing must be in trustworthy hands and under strict supervision for uniformity of bond and dampness.

Generated steam being very prominent, its easy escape has a large bearing upon the soundness of the casting. A too-damp facing-sand causes doubtfulness, whilst a dry facing needs the application of a supply of water when finishing to bring it into bonding condition for smoothing. Possibly too much may be used.

Venting may be relaxed when sands are of a good permeability. The sand to which these remarks refer having a low permeability, it is necessary further to increase porosity by the unlimited use of the vent wire and drying of certain parts. The use of the vent wire has fallen greatly into disuse.

Occasions arise when a turnover method is not possible, necessitating a pattern to be moulded in the floor. Numerous moulds made this way cause large volumes of gases to be formed, requiring for their exit a definite passage, or even an outlet for a core-vent. For this a bed of cinders is made about 9 in. below the bottom of the mould. The size of bed and quantity of ashes depends upon the size of the mould, also the speed necessary for their escape. The easier the escape, the better for the mould. A pipe is inserted from the bed to the floor level for a final outlet. Paper should cover the ashes to prevent sand mixing with them, and a partial choking of the bed. All moulds, more especially small valves, tee-pieces and globe valves, should be well vented with the $\frac{1}{4}$-in. vent wire. Commotions set up while filling the mould must free themselves sharply, otherwise they become entrapped in the quickly freezing iron, only to be discovered when machining or under test.

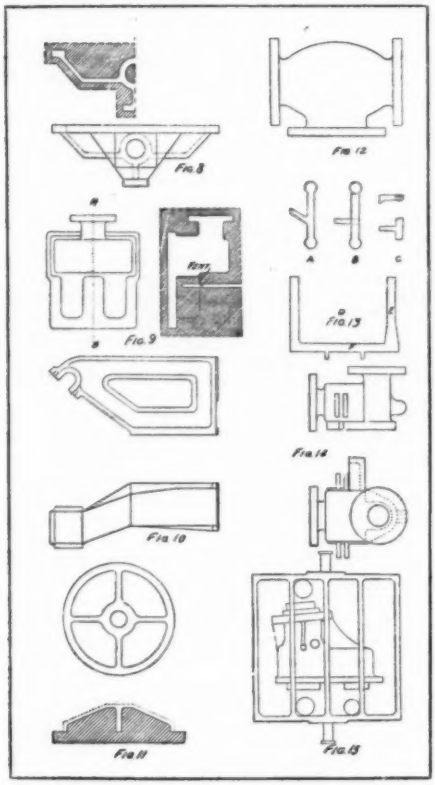
The commotions which take place may be seen when casting an open sand packing ring 12 in. deep, 3 in. thick, or by looking carefully down an open riser during filling the mould.

XUM

Moulds with branches in top parts or having pieces of mould as shown between the flange and body in Fig. 8 should be moulded with care. This is a view of a high-pressure slide valve, also a mould sectional elevation. When nearing the flange, it should be laid in position and rammed underneath instead of ramming up full and knocking it down to position. This knocking down may make it too hard, thus encouraging scabbing, which in parts like these require little encouragement, owing to gases and steam rising from mould face to mould face.

Excessive dampness here evolves an excess amount of steam in the flange, which, if it does not escape through the sand or riser, will lodge itself in the flange, the result being a blowhole in the casting. Porosity at these parts is assisted by pieces of straw laid in the sand, the vent wire, and slightly drying with a hot iron.

Fig. 9 shows an auxiliary discharge chest with a mould section, the mould of which is benefited by the addition of a stream of ashes. Gases generated when the iron enters the bottom fly upward



through the sand and through the easy ash passage. The gases from the sand between the vent and the flat mould face having an easy exit, give way to the pressure exerted by the iron. Without this passage the tendency is to make for the flat mould face. Upon the iron reaching here, a bubbling takes place, causing the face of the mould to lift away where the gases break through.

Fig. 10 shows a weigh shaft bracket, a type of pattern, if it is not possible to turnover, requires skill and care when made in the floor. It is about 4 ft. 6 in. long, 18 in. deep, and moulded as shown in front elevation. In the plan a large piece of mould will be seen which will become well surrounded with iron, making it prone to scabbing. The making of these moulds requires the inserting of a cinder bed.

For the floor-moulding valves brackets smaller than the one previously shown, or slab plates 6 ft. × 2 ft. 6 in. × 3 in. thick, no cinder bed is necessary. The bottom of the hole should be well opened up before commencing to work from the desired level, thus assisting the downward escape of gases.

The use of facing may be eliminated when making thin moulds such as thin flat plates, bodies of narrow pipes or top parts of large pipes.

Gases from facing sand retard the flow of the iron, and in pipes may affect cohesion of the metal at the tops.

Moulding with milled green-sand must be done with extreme care. Although it possesses the much-desired bond for green-sand work, its permeability is very low. Light tooling must be done, as scabbing easily appears. It is excellent for moulds which are preferably skin-dried, when it results in a good mould face.

Shortage of floor space accounts for the making of moulds in a hot hole and with hot sand. These ought to be finished off as quickly as possible. The facing sand becomes very dry, and although water may be applied, it is difficult to finish. Scabbing is encouraged by too much tooling, especially upon flat or curved surfaces.

The pile or glaze made agitates the iron, which results in bringing away a piece of the face. Fillets upon joint brackets should not be made too large. Large fillets not only affect the crystalline arrangement, but encourage sponginess. This is more easily encountered in dry sand work, as the casting cools slower, and generally undergoes a more critical test.

Fig. 11 is a view of a pump bucket cover and mould section to illustrate prominent pieces of mould. These, also flat tops made with old sand, pieces of mould subjected to the continual beat of the iron, and joint brackets, may be smeared with plumbago as a preventive for resisting the scorching effect of the iron.

Discretion must be used when applying plumbago to mould bottoms owing to the great retarding effect it produces upon the flow of the iron.

Many successful varieties of runners are to be found for the running of moulds. The straining of moulds is more often met with in green-sand work than in dry sand. Fast pouring accelerates straining, also blowing in risers, owing to steam and gases not being able to free themselves sufficiently quickly. Such blowing is often accompanied by the scabbing of flanges if the riser is upon a flange. Obviously, large thin castings should be run quickly, and in this instance due consideration must be given to the dampness and porosity of the sand used.

With the work with which the subject deals, it is preferable to use a runner which will fill the mould gradually. This allows steam and gases to find their exit through the sand and outlets provided for them; also any commotions taking place in the mould will free themselves in the gradually rising metal.

Fig. 1 is a view of a globe valve. Any bubbling taking place in this mould failing to free itself, may lodge itself in the body, and not be found until under test.

There is always a possibility of a small amount of dirt being carried down the downgate with the first rush of the metal. As a precaution, the joint runner may be extended a little farther than where it enters the mould—a kind of receptacle—or, better still, if the joint runner is not cut in the top part, sand may be cut out above this as a further preventive.

Fig. 13 illustrates a few designs of runners. A is one of the most common type; B has the runner cut in the top joint and where it enters the mould in the bottom; C shows why a runner should be deeper at the mould edge to prevent the edge washing; D is almost similar to B, and is preferable for moulds made in dry sand, which must produce a casting entirely free from dirt or slag owing to the high test they generally receive; and E is a scum-gate twice as wide as the down runner, thus allowing any scum freedom to accumulate instead of choking the bottom, with the possibility of some entering the mould. The breaking of the piece F when removing the casting is simple proof.

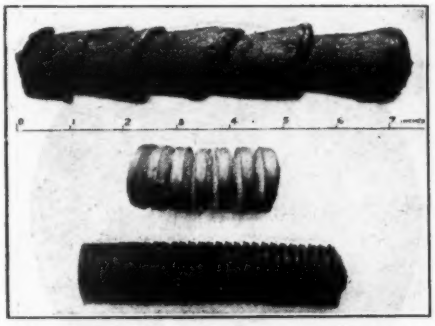
Unless supervision is strict, the occasion sometimes arises, through shortage of box space, of a mould having a drop runner upon a flange or part of a body. A round pin is more satisfactory here than a flat one. Flat and square down-runners set very much more quickly than round ones. This cuts off any chance of escape of the bubbles which are continually found when a flat gate has been broken off a casting. Round gates can be worked more effectively if further attention is required after filling the mould.

With dry sand moulds it is seldom necessary to close the risers. The nature of green sand some-

(*Continued on page 99.*)

Extruded Metal: A Dip into Pandora's Box.

(*See Page 87 et seq.*)



FIGS. 3, 4 AND 5.—SHOWING CURIOUS RESULTS OBTAINED IN ATTEMPTS TO EXTRUDE ROD UNDER IMPROPER CONDITIONS.

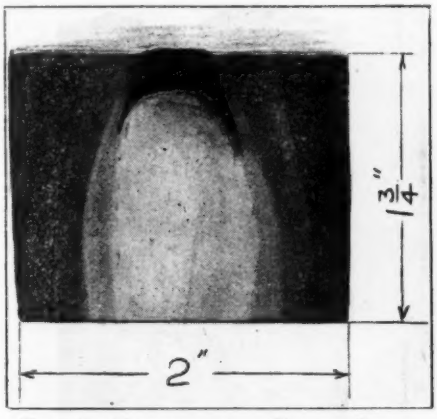


FIG. 6.—POLISHED AND ETCHED LONGITUDINAL SECTION, OF FULL WIDTH, CUT FROM A ROD OF EXTRUDED YELLOW METAL HAVING A CORE OF WHOLLY ALPHA MICROSTRUCTURE, SURROUNDED BY ALPHA AND BETA STRUCTURE; THE LATTER IN TURN IS ENCLOSED IN WHOLLY BETA MICROSTRUCTURE.

FIG. 7.—TRANSVERSE FRACTURE OF YELLOW-METAL BILLET CAST IN IRON MOULD, SHOWING OUTER RING OF COLUMNAR CRYSTALLINE FORMATION.

FIG. 13.—TRANSVERSE FRACTURE OF A DEFECTIVE YELLOW-METAL EXTRUDED ROD SHOWING LOOSE-CORED CENTRE (*Vide* FIG. 12).

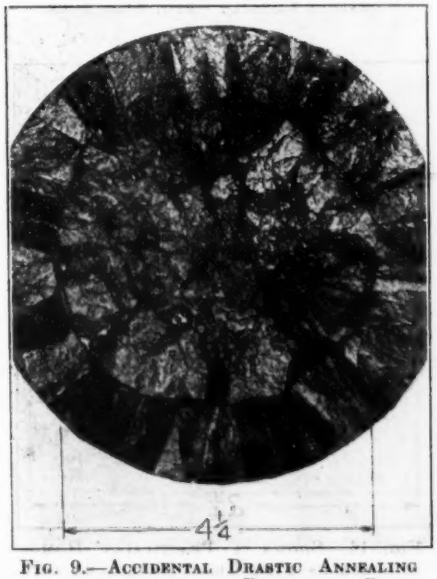


FIG. 9.—ACCIDENTAL DRASTIC ANNEALING HAS BROUGHT ABOUT PRONOUNCED GRAIN GROWTH IN THIS EXAMPLE.

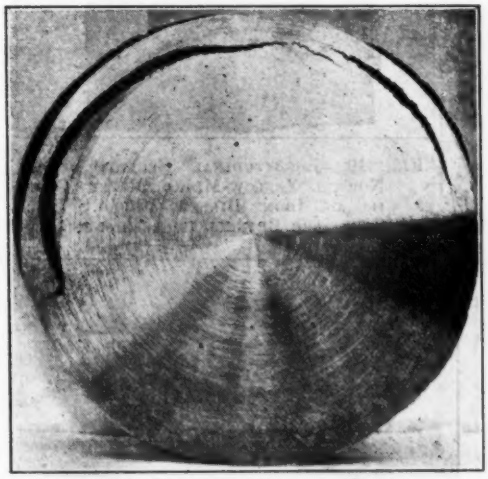


FIG. 8.—A MACHINED SECTION CUT FROM A BILLET OF YELLOW METAL, TAKEN AT RIGHT ANGLES TO THE LONG AXIS. IT HAS BEEN HAMMERED TO SHOW THE WALL SPACE BETWEEN THE TWO DIFFERENT STRUCTURES.

Extruded Metal: A Dip into Pandora's Box.

(*See Page 87 et seq.*)

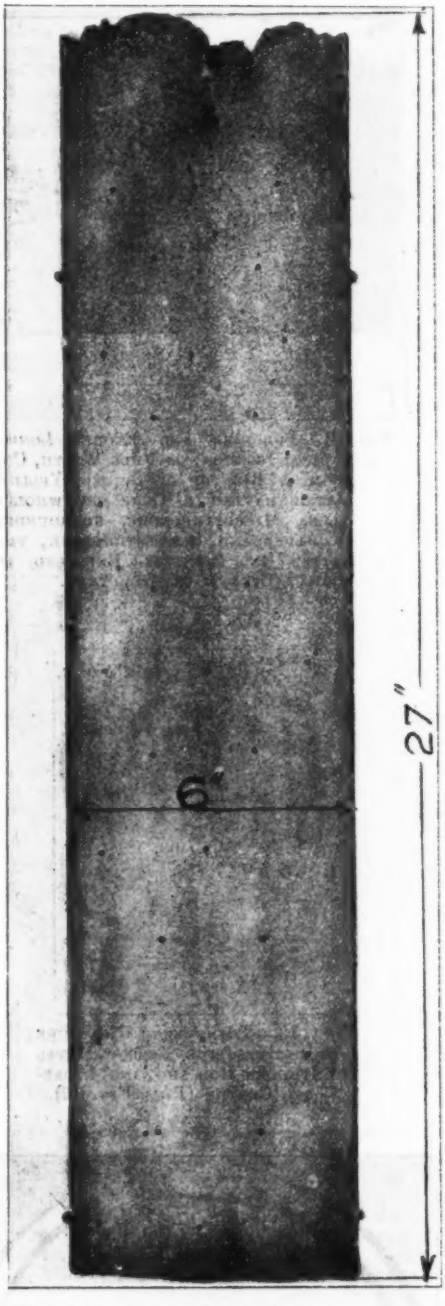
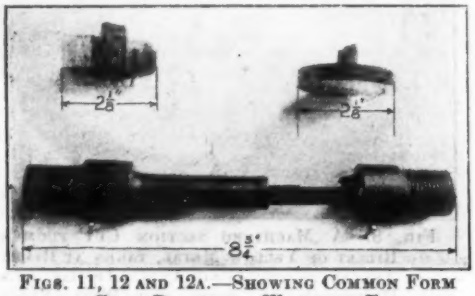


FIG. 10.—LONGITUDINAL SECTION OF A NORMAL YELLOW-METAL BILLET CAST IN AN IRON BILLET MOULD. THE SHOTS ARE BRINELL IMPRESSIONS.



FIGS. 11, 12 AND 12A.—SHOWING COMMON FORM OF CORE DEFECT IN WAR-TIME EXTRUDED ROD.

FIG. 14.—POLISHED AND ETCHED TRANSVERSE SECTION OF EXTRUDED "CORED" ROD SHOWING A CONCENTRIC OUTER ZONE OF COARSE CRYSTAL GRAINS.

FIG. 15.—THIS SECTION SHOWS A ROD OF NEARLY BUT NOT ENTIRELY HOMOGENEOUS CRYSTAL GRAIN STRUCTURE.

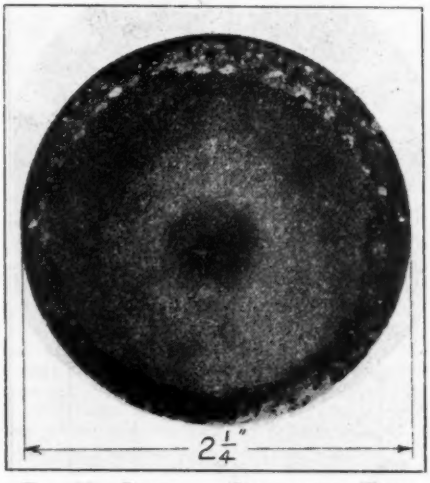


FIG. 16.—SHOWS A PRACTICALLY HOMOGENEOUS FINE GRAIN STRUCTURE SURROUNDED BY A ZONE OF COARSER CRYSTALLINE STRUCTURE.

Extruded Metal: A Dip into Pandora's Box.

(*See Page 87 et seq.*)

FIG. 17.—SHOWS ZONAL RING OF COARSER CRYSTALLINE STRUCTURE COMPARED WITH THE CENTRE PORTION.

FIG. 18.—SHOWING LARGE CENTRAL CRYSTAL GRAINS SURROUNDED BY A ZONE OF SMALLER ONES. THERE ARE TWO BRINELL IMPRESSIONS.

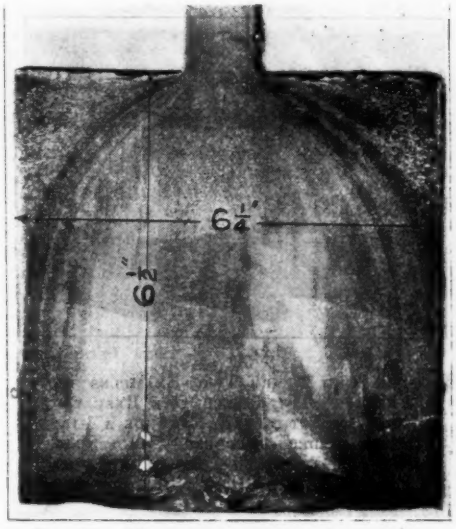


FIG. 19.—MACROSTRUCTURE OF SECTION CUT FROM DISCARD OF A BILLET WHICH HAS BEEN EXTRUDED THROUGH A SINGLE 1-IN. DIA. DIE.

FIG. 20.—SIMILAR SECTION TO FIG. 14 SHOWING EFFECT OF SHEARING DURING EXTRUSION ON THE METAL OF THAT PORTION LOCATED IN THE CORNER OF THE DIE END OF THE CONTAINER.

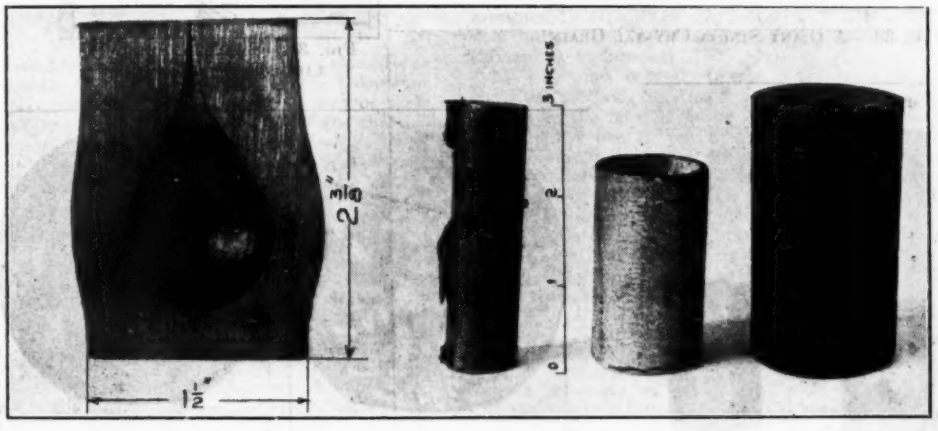


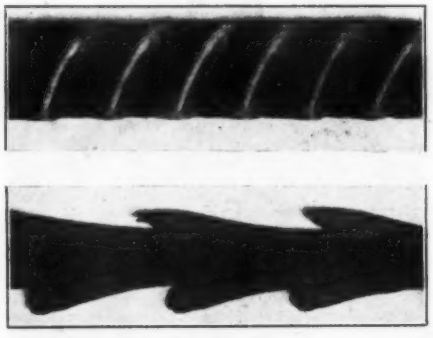
FIG. 25. FIGS. 22, 23, 24.

FIGS. 22, 23 AND 24 ARE SPECIMENS SHOWING ENVELOPING SHEATHS IN DEFECTIVE ROD, FIG. 23 BEING A DETACHED TUBULAR SHEATH OCCURING AS A LOOSE ENVELOPE. FIG. 25 IS LONGITUDINAL SECTION THROUGH A PORTION OF A 1½-IN. EXTRUDED ROD SHOWING GAS POCKET.

XUM

Extruded Metal: A Dip into Pandora's Box.

(*See Page 87 et seq.*)



FIGS. 26 AND 27 ARE TWO EXAMPLES OF FREAKS. THE LOWER ONE RESULTED FROM AN ATTEMPT TO EXTRUDE A $\frac{3}{4}$-IN. STRIP UNDER IMPROPER CONDITIONS. THE UPPER ONE WAS DUE TO A SLIGHT EXCRESCENCE ON ONE SIDE OF THE APERTURE IN THE DIE.

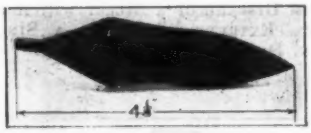


FIG. 29.—DETACHED END OF TUBE MANDRIL DRAWN OUT TO A FINE POINT BEFORE FRACTURING.

FIG. 33.—A GIANT SINGLE CRYSTAL GRAIN.

FIG. 21.—METAL REMOVED FROM THE CONTAINER AFTER EXTRUDING PRACTICALLY THE WHOLE OF THE BILLET.

FIG. 28.—MISSING PORTION OF A TUBE MANDRIL FOUND IN A LENGTH OF EXTRUDED ROD.

FIG. 30.—A CONGLOMERATE MASS RESULTING FROM AN ATTEMPT TO EXTRUDE AN OVER-HEATED BILLET OF YELLOW METAL.

FIG. 34.—SMALLER, YET QUITE LARGE CRYSTAL GRAINS.

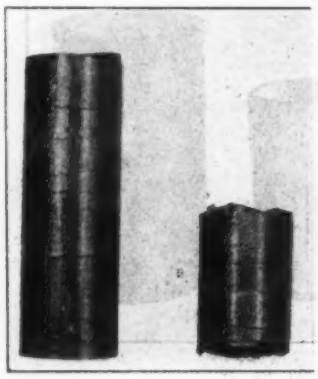


FIG. 35.—OVER-STRESSED EXTRUDED BAR WHICH CRACKED AFTER LEAVING DRAW BENCH.

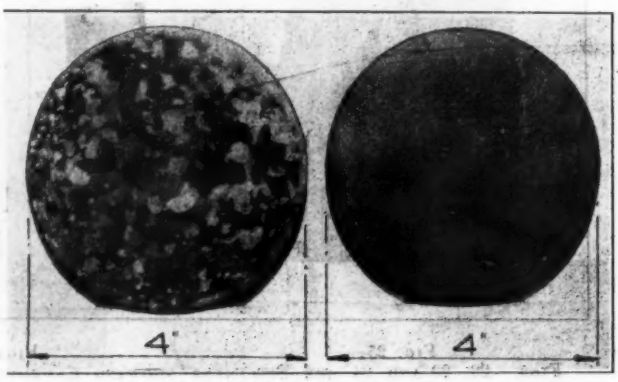


FIG. 31 AND 32.—MACROSTRUCTURE OF METAL FROM EACH END OF A BAR OF EXTRUDED METAL 4-IN. DIA.

times makes closed risers a necessity, yet it is of the utmost importance they be allowed freeness to be eased by the touch of the metal. More especially with small valves, with which it is essential to run metal through after having been eased, thus freeing any blows which may have failed to escape. The failure to ease a riser often results in a defect in a flange.

Fig. 14 is a view of a mud box which possesses many weak pieces of mould, and one where all risers should be eased. Moulds having large flat surfaces, prominent pieces of sand or femmer cores, require their risers to be securely closed. This affords a pressure to be exerted all over the face of the mould, forcing the gases through the sand and artificial means of escape instead of rushing through the mould, out of the open riser, and blowing away pieces of mould or drawing down flat top parts.

When closing dry sand moulds every precaution must be taken for dampness or steam arising from any of the constituents used whilst coring up. These may be clay for touching purposes, or too damp sand when making up prints. Special regard to this is necessary with oil sand cores.

Fig. 15 shows a top part with holes above core prints, giving a clear view for the vent to be made up without any fear of the metal entering. If the core be upon a spindle or made of sand or loam, it is preferable to bring the vent away horizontally or vertically. Cores of oil sand allow one greater freedom.

In jobbing work, chaplets play an important part in the success of a casting. Continual adding or removing of branches from patterns makes it impossible to have a core in one piece; consequently, many loose cores are encountered.

On no account should a pressure casting have a double chaplet. A stalk chaplet of suitable strength will prove satisfactory. Blowholes, which sometimes occur round chaplet nails, may be caused through the small impression or button made upon the sand being hard, as they are often made without any sand being eased out.

Gauze chaplets are suitable in mould bottoms, but one must use discretion for their use to resist uplifts. In a green sand mould they may rest upon a metal prod or flat-headed nail inserted level with the mould face.

It is not possible to advise anything definite in the making of moulds for superheat work or internal combustion castings. A few points which might be adhered to are:—A dry mould, quick running, large risers and an entire absence of anything which will produce dampness or blowing of the metal. The numerous unsound castings met with in this class of work too clearly suggest much research has yet to be undertaken.

In conclusion, the author desires to express thanks to his employers, the North-Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne, for their kindness in allowing him to give this Paper, and also to their laboratory for assistance in preparing slides, etc.

Catalogue Received.

Thermo-Electric Pyrometers.—The Cambridge Instrument Company, Limited, of 45, Grosvenor Place, London, S.W.1, have sent us a copy of their new list, 194B. The basic principles of the thermo-couple are briefly, clearly and simply described, and a number of standard types of indicators are similarly dealt with. The section, however, which is most interesting for foundrymen is that which describes and illustrates a new type of six-point recorder. They are enclosed within robust moisture and fume-proof metal cases, which are easily installed on a convenient wall. Six records are obtained simultaneously, and as the chart is clock-driven, they are synchronous. The multi-points recorded can be thus arranged to give six independent temperature records; for instance, two could follow the thermal history of the core stove, two for the mould drying over, and two for an annealing oven.

Obviously, it will economise initial capital outlay, space occupied, time for regulation, maintenance and upkeep, and less bulky files.

We understand the list is available to our readers on application.

Cleaning Castings.—II.

Modern Practice and the Draft Regulations.

By A. RUTHERFORD.

Tumbling and Pickling.

For cleaning small castings in quantity a tumbling (or, as it is variously called, rumbling, rattling or jigging), barrel is often used. This is a metal cylinder, a medium size being 2 ft. dia. by 3 ft. long, which can be made to revolve about a horizontal axis. The barrel is loosely packed with castings carefully graded to one size and weight, and included with the charge are a number of rough, broken pieces of metal, technically known as "stars." When the barrel is rotated the castings roll over and over among the stars, the sharp edges of which clean the surfaces of the castings to a matt finish.

The older form of tumbling barrel is an extremely simple appliance, and will in no way comply with the proposed Cleaning of Castings Regulations. Under these all tumbling barrels should be fitted with an exhausting plant which will carry away the dust and sand and effectively prevent pollution of the air around the machine. It is expressly stated that such an exhausting apparatus must be efficient.

An alternative for combating pollution of the air is offered which should give unlimited scope to inventors and those wishing to introduce new systems. The regulations merely state that any other arrangement may be made which "shall be proved to be at least as effective in preventing the dust from entering the room." The standard of comparison here, is, of course, an efficient draught extraction plant.

A newer form of tumbling barrel which will probably benefit greatly by these regulations, is a much more elaborate machine than the older form, combining sand blasting with tumbling. The barrel itself is perforated, and a sand or shot blast is blown through the castings as they roll over. The dust, sand, and shot find their way into a hopper which leads into a separating plant. This will be subject to the same regulations as the corresponding part of a sand-blasting plant, as mentioned in the previous article.

An old method of cleaning castings which has largely fallen into disuse for many reasons, but which still survives to a limited extent for certain classes of work (automobile cylinders) is what is known as "pickling." This consists in simply immersing the castings in dilute sulphuric or hydrochloric acid. The acid dissolves the skin from the casting and with it, of course, removes the sand. When castings have to be completely machined this method is quite suitable, as a surface without skin is very easy to machine. When surfaces have to be left rough, however, and particularly when they have to withstand exposure and resist corrosion, the presence of a skin has an excellent protective effect. Castings which have to withstand a high hydraulic pressure under working conditions work much better with the natural skin undamaged, as this is much less porous than the metal underneath.

No reference is made in the regulations to any chemical methods of treating castings. This may be due to the method being overlooked on account of its scant use, or perhaps no evidence has been available or forthcoming which would indicate that it should be subject to special regulations. Apart from proper protection from the acid, a precaution which any right-minded person would naturally take in his own interest, there would seem to be hardly anything sufficiently dangerous or capable of being made dangerous by careless handling, that might require regulation.

GAS GENERATORS & INDUSTRIAL FURNACES, LIMITED, are being wound up voluntarily, with Mr. C. Fairbairn, 6, Gray's Inn Square, W.C.1, as liquidator.

THE PROPOSAL for the sale of J. Hetherington & Sons, Limited, has received the sanction of the requisite number of shareholders, and the scheme for the purchase of the concern at 30s. per share will go through. The names of the purchasers are not disclosed.

XUM

Methods of Metal Melting.

Birmingham Metallurgists Discuss Potentialities of Diverse Processes.

At the invitation of the Birmingham Metallurgical Society members of the Birmingham Branch of the Institute of British Foundrymen took part in a joint discussion on "Methods of Metal Melting" at the Chamber of Commerce, January 15. Dr. H. W. Brownsdon presided.

MR. W. R. BARCLAY, in opening the discussion,, said to melt metals either as pure metals or as alloys demanded obviously (*a*) furnaces, and (*b*) fuels, and in these days of the application, in addition to the older established coal- and coke-fired furnaces, of gas, oil, and electricity, the various factors were much more complex and much less easy to evaluate. It must be generally admitted that each of the four sources of heat energy deserved most serious consideration of metallurgists, whatever their special field might be, whether ferrous or non-ferrous. Coke (or what might be called solid fuels), gas (both producer and town), oil and electricity, were each eminently practical fuels for one or other of the many diverse branches of metal melting, and each must be carefully taken into consideration in any decision as to the putting down of new plant or as to alteration, extension, or improvement of existing plant. It was also true, he thought, that all the various types of furnaces commonly known in metallurgical practice had each its special factor of value and one or more features of attraction. It was necessary to say this because writers in the technical Press were apt to jump to the conclusion that the more modern applications of gas and electricity to the problem of metal melting necessarily held the field, and that in time all metal melting would be carried on by one or other of these means. He frankly confessed that he had been himself attracted by some of the more recent developments in electric furnaces, such for example as the high frequency furnace introduced by Northrupp in the United States. It had been necessary, however, for a good many years now for him to bring his mind down to the somewhat sordid level of financial and economic considerations and he had been compelled to see virtues in the older types of furnaces and fuels which were not easily compensated for by the newer. What might be called the "common or garden" pit type coke-fired crucible furnace, when properly designed and built, with careful consideration to access of air and direct chimney draught was an extremely efficient and economical instrument for the melting of metals, and though he had a great longing for the supreme cleanliness, ease of control, and freedom from products of combustion, which were the distinguishing features of electric furnaces in general, he had not yet found that the compensations of the latter were sufficient to outweigh its increased cost. There were certain considerations, such as speed of melting, and temperature available, which did in many cases clearly and definitely compensate for the increased cost, and when this was the case most would unhesitatingly adopt electric furnaces. Though it was unsafe to attempt any broad generalisation he proposed, for the sake of clearness, to make an attempt, and the generalisation he adopted was (*a*) low temperature work, (*b*) high temperature work. Again, for purposes of clearness, though he was bound to sacrifice accuracy to some extent, he wanted to fix the dividing line up to 1,400 deg. and over. At or under this temperature most non-ferrous metals and alloy could be readily melted and brought to pouring temperatures. Obviously such a range included the whole of the brasses, the bronzes, complex alloys like Delta metal, gun-metal, phosphor-bronze, and a very considerable number of the ordinary alloys of nickel, nickel-silvers, nickel-copper, and so on. He ventured to put forward for consideration the proposition that for this class it was difficult to improve on the well-designed coke-fire pit type crucible furnace for joint economy and efficiency. He was ready to admit all that could be said about the fragility of crucibles, about the possibilities of contamination through products of combustion, about dirt in casting shops, and about the ash problem, but after careful study of all these he was of the opinion that only in exceptional cases could gas, oil, or electricity be substituted with real advantage. The exceptions were (*a*) where the electric current could be generated in self-contained works at a very cheap rate; (*b*) where increased prices could be obtained for special purity of product; (*c*) where considerations such as weight of the cast needed and uniformity of composition were first essentials outweighing other considerations, such as economy. He confessed that he had been often startled when exploring the possibilities of this type of furnace not only as to economy, but also as to quality of product, and he was afraid there was a tendency to exaggerate the factor of possible contamination from products of combustion. There were, of course, many imaginable conditions in which coke firing in this type of furnace could be substituted by gas or oil, but speaking from his own experience, he had not found that these two fuels offered any real compensations except where temperatures higher than 1,400 deg. were needed.

Electric Furnaces.

Turning to high-temperature work, his first instinct in dealing with metals or alloys requiring higher temperatures than 1,400 deg. C. was to take electric melting as the first proposition for serious consideration. The types of electric furnaces brought out in the last 20 years could be broadly classified as (*a*) resistance furnaces, (*b*) induction furnaces, (*c*) arc furnaces. Obviously such a division was not a clear one, but it might be taken as a rough classification. His personal experience had been almost entirely confined to the arc furnace, for which he had a profound admiration. It was extremely convenient to work, very accurate control could be exercised over temperature, and it had this supreme advantage over the other types, that the source of heating could be readily and easily cut off to give opportunity for treatment by slags, fluxes, deoxidising agents, or thermic reaction. The intelligent use of this type of furnace, and particularly the Heroult design, had enabled them to solve the most difficult problems in the production of certain delicate alloys, and he was convinced it would hold a definite place in metallurgical practice for many years to come. At the same time there was much to be said in favour of the induction and resistance types, and these would enter into practice in increasing numbers as their designers became more experienced in melting requirements. One of the chief objections urged against electric furnaces was that as a rule it was impossible economically to make small heats. This could be overcome by developing the electric resistance type, and he felt fairly sure that the intensive research work going on in this country, on the Continent, and in America in developing these types of furnaces would bear considerable fruit in the near future. He was still of opinion, however, that the great convenience of the arc type for refining as well as for melting put it in an unique class.

Gas-fired Furnaces.

Next to electricity, of course, they turned instinctively to gas as the most convenient and readily available source of heat for high temperature work, and they were bound to admit that the designers of gas-type furnaces capable of reaching high temperatures had done extremely good work during the last ten years. Gas-fired furnaces capable of reaching temperatures of the order of 1,600 deg. C. were now available, and had many advantages, such as ease of control and convenience, whilst in some degree they might be said to be economical. He confessed, however, that such furnaces were not free from serious defects, and in particular they demanded some considerable standard of intelligence on the part of the operator to regulate pressures and to obtain the correct mixture of gas and air to

ensure complete combustion. He had found, also, that the problem of refractory material in these furnaces was more difficult than in coke-fired furnaces, even when similar temperatures were being reached. In most cases this was probably due to inaccurate adjustment leading to such faults as impingement of flame and so on.

Oil Furnaces.

In the works with which he was connected it had been found that oil-fired furnaces had many distinct advantages even over gas. Here the question was very largely that of finding a thoroughly satisfactory and efficient burner. If this was available and a supply of fair-quality oil at hand, oil melting was quite a sound proposition, and his own firm had found it to be a very useful standby for small heats where electric furnace melting had not been a reasonable proposition.

He thought it would be useful if they could direct their minds to the future and give some lead to furnace designers as to ideal requirements. It was, of course, impossible to design any one type of furnace, whether coke-fired, oil, gas, or electrically heated, which would cover all requirements. So far as could be seen, no development would enable them to cover the rapidly widening field of metallurgy with any one furnace, however efficient, and it was becoming increasingly clear that they needed nearly, if not all, the existing types. What was required was that these furnaces should be developed to higher efficiencies, and by this he meant not merely economy but the quality of the work produced. They must cut down to the lowest point troubles which arose from adverse external influences being brought to bear upon metals during this process. He put this requirement as definitely higher than the more obvious one of perfect combustion and high heat efficiency with whatever fuel was used, but he was bound to point out that these two factors were intimately connected. He did not think they could ever hope to obtain freedom from trouble due to products of combustion unless at the same time they also succeeded in solving the problem of perfect combustion, and the latter problem should be solved first. In conclusion, Mr. Barclay said that, speaking as a non-ferrous metallurgist, he believed they had a great deal yet to learn from their friends in the ferrous industries. The use by the latter of producer gas in the modern Siemens open-hearth type furnace presented a high standard of melting efficiency, and he doubted whether it had yet been realised how far this particular type could be used in non-ferrous melting if ways could be found to adapt it. In America the open-hearth furnace was used for certain non-ferrous alloys with striking results from the point of view of economy of melting, and it was the one type of furnace which held out the same advantages as the arc type of electric furnace in rendering possible refining operations during melting.

Cupola Furnaces.

MR. ARTHUR MARKS said the cupola, of course, was the furnace which was of greatest interest to the ferrous man from the foundry point of view, and the open-hearth furnace, probably, from the point of view of steel manufacture. The cupola was one of the oldest of melting plants and was still, to his mind, one of the most efficient. They had to realise in connection with the iron industry that not only was the fuel a melting agent, but it was also part of the finished product. It had been too little recognised, in discussing the efficiency of the cupola and cupola melting, that its efficiency did not depend upon the amount of coke burnt per ton of metal melted, but that it depended upon the amount of perfect castings turned out of the foundry per ton of coke melted, two quite different figures. They must dismiss from their minds the conception of the cupola as merely a melting unit. It was, strictly speaking, a furnace in which could be produced two or three types of metal. Take steam-engine liners or Diesel-engine liners. It was quite easy to run them with a melting ratio of 1 to 12. Casting the metal in a large mass, the temperature of the metal was not of great importance. They did not require excess of temperature, and therefore they could use the minimum of fuel. But when running small castings, one could not produce perfect castings with a high melting ratio. Therefore, although there was a tendency to despise the cupola as an inefficient melting agent, if one realised its true function one could not but be convinced that the cupola was one of the most efficient agents we possessed. At one time he had to decide whether to put in some electrical melting furnaces, and he opposed the idea. Those who had read about American methods of melting and making synthetic cast irons might think that his decision was retrograde. His view was, however, that the cupola was efficient, and that its possibilities were only just beginning to be recognised. Until the last five or ten years the cupola had not been tackled scientifically, and its possibilities were numerous. If it was realised that the fuel was just as important as the metal charge from the finished metal point of view, one received a truer conception of the efficiency of the cupola as a producer of metal and not merely as a melting plant.

Efficiencies Related to Good Castings Output.

Reverberatory melting was not much practised for cast iron in the foundry, except in so far as it might be used in the malleable industry; but even in the malleable industry there was a large amount of work being done quite efficiently and well where there was a knowledge of the use of the cupola as a producer of metal. The reverberatory furnace was more useful on the non-ferrous side, and he had frequently melted as much as 20 tons of non-ferrous alloys in three reverberatory furnaces running at the same time. As the fuel did not come in contact with the metal, the furnace was used purely as a melting plant. Here again the question of coal per ton of melted metal was not the vital factor. They could run a reverberatory as a melting plant and ruin 6 or 7 tons of metal in about five minutes. They could run away with the metal, 5 or 10 per cent. of zinc for example, which they could not make up. Therefore, to think of the furnace even in this case purely from the point of view of melting was wrong, and they should dismiss the idea of melting efficiency per ton of melted metal and get down to the fact that what they wanted was efficiency per ton of perfect castings. If one was melting a 5-ton or, what was quite a common thing, a 16-ton propeller in manganese bronze, it would be realised how disastrous would be the presence of oxide and oxide films in the metal. It was quite easy to melt the metal in a reverberatory of seven tons capacity and to melt it efficiently so far as the melting was concerned, but inefficiently so far as the life of the propeller was concerned. Therefore it was essential in running to recognise that the furnace could only be run efficiently by maintaining a reducing atmosphere throughout the melt. Probably the emphasis laid upon direct melting economy had had more to do with disasters than they were inclined to recognise. It was therefore of importance in running any large-size reverberatory on non-ferrous metal to keep their zinc loss or volatile loss down, and in the case of large castings of the kind indicated the usual allowance was of the order of 2 per cent. loss. Of course it varied, and the zinc they required to add varied with the character of the scrap, whether it was turnings or borings or lump scrap. It was a mistake to suppose that because a plant was modern it was necessarily efficient. It was sometimes really painful to see the inefficiency of some of the mechanical chargers in existence in the British Isles in connection with foundry work.

Oil Furnaces.

As to oil furnaces, he said he had had to test some of the largest heat-generating plants in the world—oil-driven ships—and one of the greatest troubles was to get the engineering side to appreciate what one was after in obtaining thermal efficiency. Thermal efficiency could only be obtained, in the first place, by complete combustion: and in the transference from coal-firing to oil-firing there had been much retrograde work due to an imperfect realisation of the scientific factors underlying the process of combustion. Combustion to the average engineer was not so thoroughly grasped a problem as it was, of course, to the chemist and the metallurgist, and the

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devices which were put forward, for example, for the mixing of air with oil and so forth were very crude. He had seen heavy castings bolted on to the furnace front for the purpose of giving the air a circular motion in order to mix it with the oil. In the illustrated advertisements of the furnaces they would see the oil in beautiful circulation with the air due to the air passing through tangential vanes in front of the furnace. It must be remembered that the oil was passing into the furnace under a pressure of from 160 to 250 lb. per sq. in., while the air was passing in at a pressure under a few inches, and the effect of a stream of air upon a particle of oil passing in under such different conditions was negligible. It was not sufficiently realised in designing for heat production that the design must be such that it was possible to get 14 per cent. of CO_2 before one began to produce CO, and that was not possible with 90 per cent. of the oil-fired furnaces upon the market.

DR. AITCHISON said we were lacking in any real criterion for judging between the various alternative methods of metal melting. Mr. Barclay started by saying that in considering methods of metal melting one had first of all to consider the furnace and secondly the fuel, but he ventured to suggest that Mr. Barclay had omitted what was perhaps the most important consideration of all—namely, the metal. He agreed with Mr. Marks that in deciding upon the most satisfactory method of melting one had to consider what would be the effect of that particular method upon the metal itself. That problem arose in an obvious form in connection with steel. Probably if the mere question of thermal efficiency, initial cost, overhead cost, and running cost were taken into account, the ordinary method of melting by the crucible would never be employed at all. Yet that method was used, and there did not appear to be any particular likelihood that it would die out. It was of course possible to obtain the same temperature in the electric furnace as in the crucible furnace, and they could in many cases obtain the same temperature in the open-hearth furnace as was required to melt ordinary crucible steel. Yet the crucible furnace produced a marketable article, and an article which was marketed as a rule at a higher price than the product of the electric or open-hearth furnace.

MR. D. WILKINSON said that only in exceptional cases could the electric furnace improve upon the ordinary methods of steel melting. It was quite true that ultimately a furnace could only be judged by the quality of the castings produced, but that should not be pushed too far. The primary business of a furnace was not to produce castings; that was the business of the moulder. The primary business of a furnace was to produce molten metal at a suitable temperature, and of suitable composition, for the particular purpose for which the metal was intended, and when a furnace had done that it had done its fair share of the work. His experience was that steel from the electric furnace was more prone to cracking trouble than steel from the converter. Steel of the same heat from the electric furnace as from the converter did not act in the same way. Steel from the converter, he found, always ran more freely than steel from the electric furnace. One of the problems of metal melting that had not yet been solved to his satisfaction was why steel of the same composition, at the same temperature, and, as far as one could judge from microscopic examination, of exactly the same structure should give different results. In the electric furnace one could produce steel which was as free from occluded gases as it was possible to make it, and the conditions generally were ideal, but the electric furnace was by no means so economical as the converter or open-hearth furnace. He surmised that in the electric furnace they obtained steel which was so completely free from occluded gases that they had the maximum contraction of the metal. In the converter, on the other hand, they passed such a large volume of air not only over the metal but actually through it that in converter steel they had the maximum amount of occluded gases that it was possible for steel to contain. It was quite conceivable that the occluded gases in converter steel acted in a way that opposed the contraction of the steel on cooling, whereas there being the minimum amount of gases in steel from the electric furnace, there was the minimum amount of opposition to the contraction of the steel. Despite the fact that steel from the electric furnace produced casting cracks while converter steel did not, steel from the electric furnace was really better in that it was freer from occluded gases, was denser, had a slightly increased specific gravity, and that would naturally give it a rather longer life.

DR. F. JOHNSON thought that with the advent of purer metals a great deal of the romance of metal melting was passing. He was thinking particularly of the refining of copper. Before the days of electrolytic copper there were innumerable brands of pig copper which had to be taken in hand by the refiner and brought up to merchantable quality, and the refiner had great difficulties to contend with. It was indeed an art to produce good merchantable copper from some of the brands which existed in those days.

I.B.F.—Newcastle Junior Section.

At a meeting held in the Y.M.C.A. Buildings, Newcastle-on-Tyne, on Saturday, January 17, Mr. J. E. O. Little read a Paper entitled "Brasses and Bronzes." The President (Mr. E. J. Rang, B.Sc.) presided.

In his opening remarks, the lecturer made reference to the fact that in the olden days brasses were mostly utilised for ornaments, although, of course, brass implements were also made.

By varying the composition, brass could be made hard and strong or sufficiently ductile to be drawn into wire or hammered into sheets. For ordinary purposes, brass scrap metal, containing small amounts of tin, lead, and iron, usually could be used.

Other metals were added to brasses according to the properties which were required. Lead did not alloy with the brass but separated into globules and films between the crystals. This separation of crystals was advantageous when the casting had to be machined.

The addition of tin, up to 1 per cent., was beneficial also, in that it rendered the brass less liable to corrosion in sea water. More than 1 per cent. of tin, however, caused an increase in brittleness and hardness. Iron was sometimes added to brass to produce a stronger and harder alloy.

The uses of bronzes also varied from the hardest of bearing metals to castings such as church bells. Gunmetal was foremost in consideration, and was sufficiently tough and hard to warrant its use for guns in the olden days before steel came to the fore.

For strength and elasticity bronze should be as free as possible from lead, zinc, and iron. Lead was usually added to bronzes for bearings and for statuary. Zinc, when added, acted as a dioxidant and, consequently, gave a more fluid metal and helped to give castings free from pinholes. It should not exceed 2 per cent., or the bronze would be weaker although harder.

Another bronze, of a somewhat different class, was white bronze bearing metal. This alloy was extremely soft, and bearings filled with it, if to be used for heavy loads, must be of large area.

Of the special bronzes, perhaps phosphor bronzes were the most important, although their superiority was due only to the oxide-removing qualities of the phosphorus. Owing to its resistance to corrosion, which is chiefly due to the absence of oxides, the alloy was used for machinery working in liquids. Phosphor bronze, containing 0.2 to 2.0 per cent. phosphorus, was an exceptionally good bearing metal in that the phosphorus and copper formed a copper-phosphide which was extremely hard. It was chiefly used for worm wheels, sliding faces, piston rings, etc.

Aluminium bronze generally contained to 10 per cent. aluminium, but if this content was exceeded it caused brittleness. Great care must be exercised in the melting of aluminium bronze owing to the ease with which the aluminium was oxidised. Aluminium alloys contracted considerably on cooling, and this had to be allowed for in the casting by providing large gates and a good head of metal.

The Paper aroused an excellent discussion, at the conclusion of which a vote of thanks, proposed by the President, and seconded by Mr. G. Elston, was accorded to the lecturer.

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Institute of British Foundrymen.

Birmingham Branch.

DR. WERNER ON PEARLITIC CAST IRON.

The Branch held a joint meeting with the Birmingham Metallurgical Society on January 8 for the purpose of hearing an address by Dr. S. G. Werner, of Dusseldorf (President of the Iron-founders' Association of Germany), on pearlitic cast iron. A number of slides were shown which speakers described as the finest they had seen. There was a large attendance, over which Mr. Thomas Vickers (President of the Birmingham Branch of the Institute) presided.

DR. WERNER said he thought the subject of pearlitic cast iron was one which ought to have been treated by a scientist rather than by a practical foundryman, which was what he claimed to be. He had, however, tried to compile some information which he hoped might prove of interest. There was no doubt that the pearlitic structure gave cast iron of the highest quality. Lanz pearlitic castings had consistently the same qualities throughout, and a foundryman was able to produce the desired structure with absolute certainty. The inventors had developed curves by which it was easy to ascertain the speed of cooling for each cross section in relation to the mixture of iron. The total content of carbon and silicon for the production of pearlitic castings was 4 per cent., and for this mixture of iron a curve was shown indicating the cooling rate. Comparative tests on an alternating impact machine showed that pearlitic cast iron had an increased resistance against impact—in one instance almost one hundred times that of the best cylinder iron. Usually it was about ten times as great.

Tensile Strength.

The tensile strength was not less than 14 tons, and that could quite easily be increased to 19 tons by carefully following the methods of Lanz. It was often stated that the production of cast iron according to Lanz would increase costs and complicate the work of the foundry, but it was not so. The only additional cost was in the heating of the moulds, and this was more than compensated for by the advantages. It had been said that castings with pearlitic structure could only be produced where there was no variation in the cross-sections. He would show slides, however, which would prove that it was possible to produce castings with perfect pearlitic structure with sections of varying thicknesses. For the process it was not necessary to make any material changes in the foundry or in the way of installation of new machinery. Another advantage was that they did not need to buy any special grade of pig-iron, standard grades proving satisfactory. He had even found that it was possible to use pig-iron of a lower quality than was usually used for cylinders.

White Test Bars—Grey Castings.

He had always advocated the use of scientific knowledge in the foundry, but it was certain that the average foundryman had not paid sufficient attention to the developments of science. This was a great mistake, as the proper use of scientific knowledge combined with practice was the only means by which success could be attained. The first slide illustrated how, with a silicon content of 0.51, a grey structure was obtained, while he understood that it was not possible in any other way to produce, for instance, a 2-in. bar having a perfectly grey structure with a silicon content of 0.51 per cent. The bars had now been tested, and in the first place they had been submitted to transverse tests, and showed 32 kilograms. That was the amount of transverse strength required by the German Foundrymen's Association for high quality castings. The test bars which were white could not be submitted to all the tests on account of the fact that they were not machinable. The 2-in. bar which was submitted to a transverse test, poured in a cold mould, showed a very high transverse stress, the cause being the amount of cementite in the bar; but the same bars cast in pearlitic moulds showed the same high quality under the transverse test. The deflection was very much higher for the bars out of the pearlitic mould, and the tensile strength was about half of the transverse strength. An interesting fact was that the hardness of the test bars cast in cold moulds was very much higher than the hardness of the bars cast according to the pearlitic methods. Another interesting fact was the very large increase in ductility.

Ductility of Pearlitic Cast Iron.

To enlarge their knowledge of the effect of pouring castings according to the Lanz pearlitic method, the inventors took a bar and treated the mould and the bar in three different ways. With an analysis of less than 1 per cent. of silicon, and carbon only 3 per cent., they produced white iron and a perfect pearlitic structure. Foundrymen would now be able to produce difficult and complicated castings of the highest quality because they could be sure that in every cross section, regardless of the thickness, they would have perfect pearlitic structure. The absence of blowholes (shrinkage) in pearlitic cast iron made Lanz pearlite very suitable for complicated castings such as cylinders. Moreover, it was possible to cast cylinders without feeding. Undoubtedly there was a field for cast iron which was only open when pearlitic methods were used. For instance, complicated castings had to be made out of cast steel or malleable iron on account of ductility which was wanted; in many cases, however, it was sufficient if the ductility was very small. If, for example, malleable iron with a ductility of 2 or 3 per cent. was sufficient, then pearlitic cast iron showed enough ductility in a great many cases. Where cast steel was being used which contained only about one-third pearlite and all the other part of the structure was ferrite, the ductility was greater, but the uniformity and homogeneous structure was absent.

Abrasion Tests.

Pearlitic cast iron had a very high resistance to abrasion, and therefore was especially adapted to gears. He mentioned the case of a gear which had been running in a tractor, and which on examination showed that the teeth of a pearlitic cast-iron gear as compared with hardened-steel gear had worn very much better.

As to the making of motor cylinders, Dr. Werner expressed the firm belief that foundrymen would be bound to turn to the pearlitic process. They had such varying cross sections that it was very difficult to cast them with even structure. Further, it was required of motor cylinders that they should have very good wearing properties, and it was usually recommended to use a very hard mixture. Working according to pearlitic methods, they could use a mixture with silicon about 1 per cent. and obtain a perfect pearlitic structure throughout. He had tried to study the different analyses used by the leading motor-cylinder foundries, and the cylinders of a good many cars were examined. Test pieces were taken, and it was found that each firm had its own analysis, but that they varied even when taking cylinders produced by an individual firm.

Growth.

One of the most valuable properties of cast iron produced according to the methods of Lanz was that it did not grow. Tests showed that if they wished to avoid growth of the cast iron when it was heated up or cooled down they had to decrease the silicon in the analysis. In his own tests, cast-iron test bars were submitted to temperatures ranging from 600 deg. to 1,000 deg., and six different kinds of cast iron were used. They found that the different kinds of cast iron, though their analysis did not vary to a large extent, behaved quite differently when they were submitted to different heat treatments. The test bars were 4 in. long and ⅞ in. dia., and they were first submitted for six hours to temperatures of 600, 700, 800, 900, and 1,000 deg. After each

heating their dimensions were measured. Afterwards the test bars were again heated four times for four hours at 900 deg. and their dimensions were re-measured. As he had indicated, the behaviour of the various classes of cast iron was very different; whereas pearlitic cast iron showed a deformation of only 0.72 and 0.766 per cent., the ordinary iron grew during the first period by 4.6 per cent., swelled after the second heat treatment to 8.76 per cent.

Hydraulic Pressure Test.

A most interesting slide illustrating a special, placed for a refrigerating engine, was shown which had a thin casing cast on the outside to stand a pressure of 20 atmospheres. The body of this casting was of different section up to 1¼ in. thick. Many attempts had been made to produce these castings by ordinary methods with unsatisfactory results. They were made of pearlitic iron and tested, and the casing was submitted to a pressure of 200 atmospheres before bursting. Afterwards four sections were removed from different points, and the micros. were shown on the screen, which proved that true pearlitic structure existed throughout the different section. A piece of the case was recovered after bursting, and was submitted to impact test, and withstood 110 impacts before breaking.

DISCUSSION.

Importance of Metallurgical Control.

PROFESSOR THOMAS TURNER (President of the Institute of Metals) thought their first reflection, after the interesting lecture to which they had listened, would be that very great progress had been made in connection with their knowledge of the structure and properties of cast iron during comparatively recent years, and that in cast iron they had a very much more trustworthy and valuable material than formerly, provided castings were properly made. It was true they sometimes spoke of the wonderful quality of the castings made by their forefathers, and it had been his pleasure to examine some castings of considerable age, but he thought it could be said that no castings made by their forefathers were better than the castings made to-day, while we could make them in larger quantities and with greater regularity. As had been pointed out, our scientific knowledge of cast iron started from the chemical side. We first had to ascertain the influence of each of the constituents and the amount of the various elements that might be present without disadvantage. They knew that certain elements like manganese and silicon affected the matrix, and that their effect was often beneficial but relatively small. Ultimately it was the carbon upon which they had to fix their attention. The form in which the carbon existed was affected by the composition of the other elements present and by the rate of cooling. He was interested to hear the figure of 4 per cent. as the total of silicon and carbon. He was reminded of something that happened forty years ago when he made experiments on silicon in cast iron, and when the bar which gave the best result in a series in a 1-in. section contained about 2.2 per cent. carbon and 1.8 per cent. silicon. The next stage, of course, was the question of the structure of cast iron. The importance was demonstrated of fine-grained graphite as distinct from flaky and large graphite, which was a source of weakness. Graphite was always a source of weakness; it never gave strength. All they could do was to diminish its ill-effects by distributing it as uniformly as possible and by isolating one part from another. In other words, it was desirable to produce it in a small flake or almost granular condition. Arnold had shown that in steel the maximum tensile strength was obtained with about 0.9 per cent. carbon, or in other words with a steel which under normal conditions gave an entirely pearlitic structure. He was talking of plain carbon steel, normally treated. What they wished to obtain in cast iron was the same structure, but it did not follow that they would get a complete pearlitic structure in cast iron with just 0.9 per cent. of carbon. As a matter of fact, they would generally get it with less, because the solubility of carbon was influenced by other elements, and particularly by silicon. Therefore, the maximum strength would be obtained with a somewhat smaller percentage of carbon combined in the pearlitic form. Most of these facts had been known for a long time, and the question had been how were they to obtain a structure which was pearlitic? The method explained by Dr. Werner was intended to help foundrymen to obtain that result. They had seen some very beautiful photographs of entirely pearlitic material, and it was astonishing when one realised that some of them were from very thin sections and some from thick, and from irons of different composition. The moral to all of them was pretty plain, and that was that the foundryman of the future would require to have more scientific knowledge than his father or grandfather had and more scientific control. He must know not only the composition of his material—and that they had been trying to impress upon foundrymen for a long time—but he must also study the rate of cooling of the casting. Having been interested in cast iron for a good many years, he was pleased to feel that they could, by the application of knowledge now within their reach, ensure material of a high quality and of a uniform character, material that could be depended upon to resist shock, to give good wear, to give smooth running surfaces, wearing surfaces, and which would not creep or grow unduly when it was exposed to high temperatures.

Elasticity in Cast Iron.

MR. ARTHUR MARKS said that it had been recognised by metallurgists for some time that structure was the essential factor in strength, and that it was possible to obtain the same structure with varying compositions. It happened that Dr. Werner and his colleagues in Germany had been working along lines which he (the speaker) followed in connection with Diesel engine manufacture. It was one of his regrets that he was unable to persuade the people concerned to secure for Britishers the pearlitic cast-iron structure. Pearlitic cast iron had been manufactured and studied under similar conditions to those obtaining in Germany. There was nothing in Dr. Werner's lecture which could be refuted, and there was nothing which had not been carried out experimentally on a large scale in works in the British Isles. Some of the photographs shown were exceedingly beautiful, and demonstrated the perfection of the optical work of Germany. The difficulty of obtaining high-class microphotographs in this country was considerable, and some of our laboratories were not provided with suitable equipment for the purpose. We had, of course, made enormous strides in this matter, and in the application of science to foundry work in later years. But one of the difficulties at present in regard to impressing the utility of pearlitic cast iron on the mind of the engineers who had to use it was to convince them that they were going to get the necessary elasticity. Every practical engineer knew that he could get tensile strength, but having procured that, was he also going to obtain the elasticity he required? Dr. Werner had shown that with the pearlitic structure it was possible to get a large percentage of elasticity. He (Mr. Marks) had made bars of pearlitic cast iron which it was possible to bend and to get a certain amount of permanent deflection upon. They could also get a certain amount of elongation in the tensile test, which was one of the best tests for cast iron that it was possible to make. He hoped that it would be brought home to British industry that unless there was a more complete application of science to industry we should rapidly fall behind.

Shrinkage in Pearlitic Cast Iron.

MR. E. LONGDEN asked what became of shrinkage in pearlitic cast iron if headers were not needed. Was not that proof positive that it was possible to produce sound cast-iron castings if gases were eliminated. Dr. Werner had referred to the desirability of moulding large turbine castings so that they could be cast by the pearlitic method. He (Mr. Longden) regarded it as extremely difficult to mould a large turbine casting, such as a housing, for example, which took a considerable time to core up—sometimes weeks. Personally, he did not think it was possible to produce large castings in pearlitic cast iron. Dr. Werner had referred to the heating of certain moulds up to 500 degs. C., and he would like to

know what class of sand would stand up properly to the wash of metal after having been heated up to that extent. He imagined it would require a special quality of sand. Sands contained various mixtures such as coal dust, manure and other things which would perish when submitted to such a high temperature. In his view, also, the moulding of large castings to produce the pearlitic structure would be prohibitive as regarded cost.

Electric Furnace Cast Iron.

MR. D. WILKINSON recalled that some six or seven years ago he had the privilege of making a considerable amount of grey iron in an electric furnace. In the first few experiments the heat was intense when it was first tapped. The moulds were taken out of the stove not more than ten minutes before the metal was ready, and he imagined the temperature of the moulds then would be in the neghbourhood of 450 degs. He thought it might therefore be taken for granted that it was quite possible to heat up metal to that temperature and yet have it in such a condition that it would readily resist impact and fulfil its purposes satisfactorily. The thing that struck him about the castings was that they could be bent by hitting them with a hammer. The chemist and he for their own satisfaction polished up a few sections and examined them. Certainly the amount of pearlite in them was pretty considerable, although he could not remember whether the structure was entirely pearlitic. He judged, however, that they had there and then made pearlitic cast iron. He did not know whether he was right, but it seemed to him that one of the points in obtaining a pearlitic structure was the slow cooling through the freezing point, enabling the pearlite to develop to the fullest and most complete extent. Really by casting metal as hot as possible, even in a cold mould, they were approaching somewhat the conditions necessary for the method described of obtaining a pearlitic structure throughout the whole casting. That cleared up one matter that had been more or less obscure as to why really hot metal put into a good, sound mould gave a better casting than cooler metal put into the same mould. It seemed to him that there was a very big future for the process of obtaining the pearlitic structure in cast iron. It would be agreed that a definite uniformity of structure could be obtained, and a structure which they knew from metallurgical experience was the strongest among all the compounds of iron. If they could definitely obtain this structure throughout an entire casting they would have a strong, sound casting which would stand stresses and shocks to the maximum degree. That, of course, was what they were seeking, and he was under the impression that many of them would go away determined to think deeply over the process and see if they could not do something in the same direction. He understood licences were available. In view of the experience of British foundrymen it seemed to him that there would be a great deal of difficulty in upholding the patent in this matter. He was not, of course, speaking as a lawyer. But the fact remained that he was acquainted with several foundrymen who regularly cast steel into hot moulds. Naturally, if German foundrymen had developed the process thoroughly the credit was theirs. Difficulty was also introduced by the fact that it was the regular practice in many foundries to cast, for example, motor cylinders in warmed moulds.

MR. T. TURNER, JUNR., expressed the thanks of the Metallurgical Society for permission for its members to be present, and asked Dr. Werner to what extent in percentage of output of the whole of the cast iron in Germany was pearlitic cast iron now being used, and since it had been used to replace steel for electrical purposes he would also like to know what were its electrical properties. The lecture should indicate to them a line of thought. For thirty years, perhaps, they had had the chemistry of the foundry brought to their notice. Mechanical properties had always been kept before their eyes by the engineer. They had been apt to look at the chemical properties one by one, and modern practice was much the same as it was when the influence of silicon was pointed out. Foundries would find it worth while to discover an expert in moulds. So far no university or technical college made a speciality of the technique of moulds and moulding temperatures, but that would have to come.

Dr. Werner was cordially thanked for his address.

THE LECTURER'S REPLY.

Replying upon the discussion, DR. WERNER claimed that by the new method they would deliver better castings to their customers and by that means increase their business. The reason he spoke of blow-holes and not of shrinkage cavities was that his use of the words embraced both. Of course, the Lanz pearlite process diminished shrinkage cavities as well as blow-holes. Hot pouring was always the right thing to do. It was quite possible to cast large castings without headers. He had found it possible to cast cylinders weighing 3 tons without headers. He had seen quite a number of cylinders weighing more than 1 ton and which were all cast without headers. It was not at all difficult to mix a moulding sand which would stand up to a temperature of 500 degs. C. As to the heating of a big mould for a steam turbine housing, he said there was a new kind of drying stove, and the inventor's idea had been referred to in the FOUNDRY TRADE JOURNAL. Pre-heated air and high pressure was used. This was let into the stove and the whole mould closed up entirely. The heat was driven by the high-pressure gases into the mould, and if they watched one of these moulds they would see how the gases and the vapour came out at every little hole. After a time the vapour was no longer visible, and the mould was dry. They then put a pyrometer or thermometer into the mould and heated to the required temperature. This system could give them far more than 500 degs.

German Effort for Research.

Personally he believed that for certain purposes it was necessary to use an electric furnace to melt iron. They could not expect to get the purely pearlitic structure unless they followed the Lanz methods. As to phosphorus in pearlitic cast iron it was desirable to have it as low as possible. He was unable to answer the question regarding the percentage of production of pearlitic cast iron in Germany. Most of the licences had been taken out during the past year, and at the present time twelve of the leading firms in Germany held licences. They had combined into an Association to protect the patent in Germany, and at the same time they had formed a society for the study and improvement of cast iron. They were anxious to support the professors and metallurgists and scientists at the universities and technical colleges who were working on cast iron, because the Government was not able to equip the laboratories as they did before the war on account of lack of money, and it was the intention to see that the work did not suffer from that cause. So the firms had decided to put up the money themselves to assist those who were working on the improvement of cast iron. The electrical properties of the iron had not been determined. He should think, however, that if the cast iron was submitted to any electric influence that the homogenity and uniformity of its structure would be an advantage.

Publications Received.

A Few Notes on Pension Schemes, by F. B. Reynolds. Published by Messrs. Muir, Beddall & Company, Limited, 4, Bucklersbury, London, E.C.4. Price 1s. The object of this book is to arouse the interest of employers of labour in the institution of pension schemes for employees. His story is told in simple non-technical language, and is very convincing as to the desirability of the institution of pension schemes.

Monthly and Yearly Highest and Lowest Prices. Published by Fredc. C. Mathieson & Sons, 16, Copthall Avenue, E.C.2. Price 2s. 6d. This sixteen-page book is very interesting, but very depressing for the metallurgical industries, as the average 1924 price of shares of every British company coming within the category of iron, coal, etc., is lower than the average 1923 price. Readers who interest themselves in stocks and shares are enabled to get a bird's-eye view of movements spread over the last six years for a study of this book.

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Trade Talk.

THE RIMA STEEL CORPORATION (HUNGARY) are negotiating with a New York house for a loan of between $3,000,000 and $5,000,000.

BRITISH PIG-IRONS, LIMITED, Abbey House, 2, 4, 6 and 8, Victoria Street, Westminster, London, S.W.1, have increased their capital to £20,000.

THE PELABON WORKS, close to Richmond Bridge, are being disposed of in sections. At these works the "Rubis" sparking plug was made by Pelabon, Limited.

THE BRITISH EMPIRE STEEL CORPORATION announces that three open-hearth furnaces and a blooming mill will resume operations early in February, after being closed down for several months.

THE TENDER OF Thos. Piggott & Company, Limited, Atlas Works, Birmingham, for the supply of steel pipes for the Taf Fechan water supply at £100,000 is understood to have been accepted.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, have secured an order from Dorman, Long & Company, Limited, for the cranes required for the erection of the Sydney Harbour bridge.

NEWTON, CHAMBERS & COMPANY, LIMITED, are erecting two houses of cast iron at Mortomley, the whole of the material to be made at the firms' works. The plans for these two houses, allowing each 6 rooms of ordinary size, with bathroom, have been approved by the Wortley Council.

DURING 1924, 470 engineering firms, with capital aggregating £3,736,395, were registered, according to Jordan & Sons, Limited, Chancery Lane, W.C.2. In addition 295 iron, brass, etc., companies, with capital £8,719,755, and 263 mining concerns (capital £7,746,925) were registered.

THE STEEL RAIL MILLS at Moss Bay, Workington, were restarted again last week, and there is every prospect that they will continue in operation for some time. An order for 15,000 tons of steel rails has been booked by the United Steel Companies, Limited, and will be executed at Workington.

THE SEVENTH MEETING of the session of the Association of Mining Electrical Engineers (North of England branch), was held at Newcastle recently. Mr. S. A. Simon (branch president) presided. A paper entitled "Flame Proof Enclosures" was given by Prof. R. V. Wheeler.

THE DIRECTORS of Hurst, Nelson & Company, Limited, propose to increase the capital of the company to £600,000 by the creation of 200,000 new ordinary shares of £1 each. The general reserve fund is to be capitalised to the extent of £100,000 for this purpose, and 200,000 ordinary shares are to be issued by way of bonus and credited with 10s. paid up, the remaining 10s. to be payable on the allotment and acceptance of the new shares. The shares are to be distributed to holders in the proportion of one new to every ordinary share held.

THOS. W. WARD, LIMITED, of Sheffield, have now purchased, for dismantling, the Listowel Mono-Railway, which is the only railway of its kind. The railway is ten miles long, and has been worked continuously from 1887 until October last year. The railway itself runs on trestles of wrought-iron and steel, 3 ft. 6 in. high, with main carrying rail on the apex, with side rails to steady the load, which is equipoised on the main rail. The main rail was originally 30 lbs. per yard, and the side rails 11 lbs. per yard. The railway has been sold because it was worn out, was running at a loss, and was not included in the Free State Railway amalgamation scheme.

THE ANNUAL MEETING of the Yorkshire branch of the Institution of Mechanical Engineers was held recently at Leeds. Professor G. F. Charnock was in the chair. The financial report for the year was adopted, and for the three vacancies on the committee, Professor Charnock, Mr. F. Clements, and Dr. W. H. Hatfield were re-elected. Messrs. Kidd, Lea, Loving, and Swift were additionally elected. Professor Charnock was also re-elected chairman of the Yorkshire branch. Following the formal business, Mr. W. B. Lewis read a Paper on "The Scientific Treatment of Boiler Feed Water, introducing the Colloidal Aspect."

THE LONDON IRON AND STEEL EXCHANGE annual dinner will take place at the Trocadero Restaurant on Tuesday, February 3. Mr. H. J. Skelton, the chairman of the Management Committee, will preside, and amongst the guests will be Mr. Henry Bond (Richard Thomas & Company, Limited), Sir Cecil Budd (British Metal Corporation, Limited), Mr. R. Dennison, M.P. (Iron and Steel Trades Confederation), Mr. A. Dorman (Dorman, Long & Company, Limited), Mr. W. L. Hichens (Cammell, Laird & Company, Limited), Rt. Hon. John Hodge (Iron and Steel Trades Confederation), Sir William Larke (National Federation of Iron and Steel Manufacturers), Sir Peter Rylands (Rylands Bros., Limited), and Mr. Harry Summers (John Summers & Sons, Limited).

Obituary.

SIR GUILFORD MOLESWORTH, the eminent engineer, died at Manor House, Bexley, last week, at the age of 96. Practically the whole of his engineering career has been in association with railways, including the L. & N.W. and the L.B. & S.C., and subsequently India, Ceylon and the East. In November, 1862, he published his "Pocket-book of Engineering Formulæ."

MR. W. B. M'HARDY, who died at Landrick House, Dunblane, last week, took up the profession of engineering, and after spending several years in the Fairfield Company's yard he, in 1907, assisted to start the Grampian Motor & Engineering Company's Works at Causewayhead, near Stirling. Along with the late Mr. R. H. Barnwell, one of the pioneers of aviation in Scotland, he designed the Grampian marine engine. Mr. M'Hardy was 45 years of age.

MR. W. S. VAUGHAN, partner in the firm of Vaughan & Dymond, of Newcastle, died recently at the age of 81 years. A native of Birkenhead, he was educated in Scotland and served his apprenticeship on the Clyde. Later he went to Tyneside, and ultimately established a very large practice as a consulting engineer. He was one of the founders and first chairman of the Blyth Shipbuilding & Dry Docks Company, Limited, and was also chairman of Walter Scott, Limited.

Gazette.

THE ADJOURNED public examination of Mr. F. J. Owen and Mr. T. H. Owen, who had carried on business as Owen Bros., at Chappell Chambers, College Street, Swansea, as metal merchants, was resumed at Swansea recently. The liabilities were £6,794, and the deficiency £6,679. The failure was attributed to insufficient capital, depreciation and losses through fall of prices in the open market, and bad debts. Debtors were questioned as to a claim against them of Messrs. Baldwin for £980 1s. 2d., an amount overpaid to the debtors. Asked if they had any idea how Messrs. Baldwin came to overpay them, they replied it was in respect of short delivery and breach of contracts. They said it was not their custom to weigh scrap sold by them to works. They took the weights of the people they purchased from, and these were checked by the firms they sold to. He admitted being in communication with someone to get weights passed. The Deputy Official Receiver: Did you invoice for more material than was sent in?—On his weights. Have you paid him anything for it?—Yes, all the time. What did you pay him?—£180. The Registrar decided to adjourn the examination, and in the interval to read the transcript of the evidence in consequence of the disclosures at the last moment, which, he said, might be of a serious nature.

Personal.

SIR BENJAMIN LONGBOTTOM has been re-elected chairman of the Engineering and Metals Section of the Manchester Chamber of Commerce. Mr. L. F. Massey has been re-elected vice-chairman, and Mr. H. Allcock hon. secretary.

MR. T. JOHNSON, who has served under the Consett Iron Company, Limited, for between 11 and 12 years, and for the last few months has been manager of the Templetown Coke Works, has been the recipient of a presentation from the officials and men. He is leaving for Dowlais to take charge of the by-product plant of Guest, Keen & Nettlefolds, Limited.

MR. E. J. DOVE resigned his position of managing director at the recent annual meeting of Wailes Dove Bitumastic, Limited, and Mr. Charles Macdonald resigned his position as assistant managing director. These gentlemen's services are still retained as directors of the company, and Mr. W. H. Dick, who has been for some years assistant managing director, was elected managing director of the company.

Wills.

JEWELL, G., Hill Crest, Beeches Road, West Bromwich, Staffs., metal merchant ... £78,829

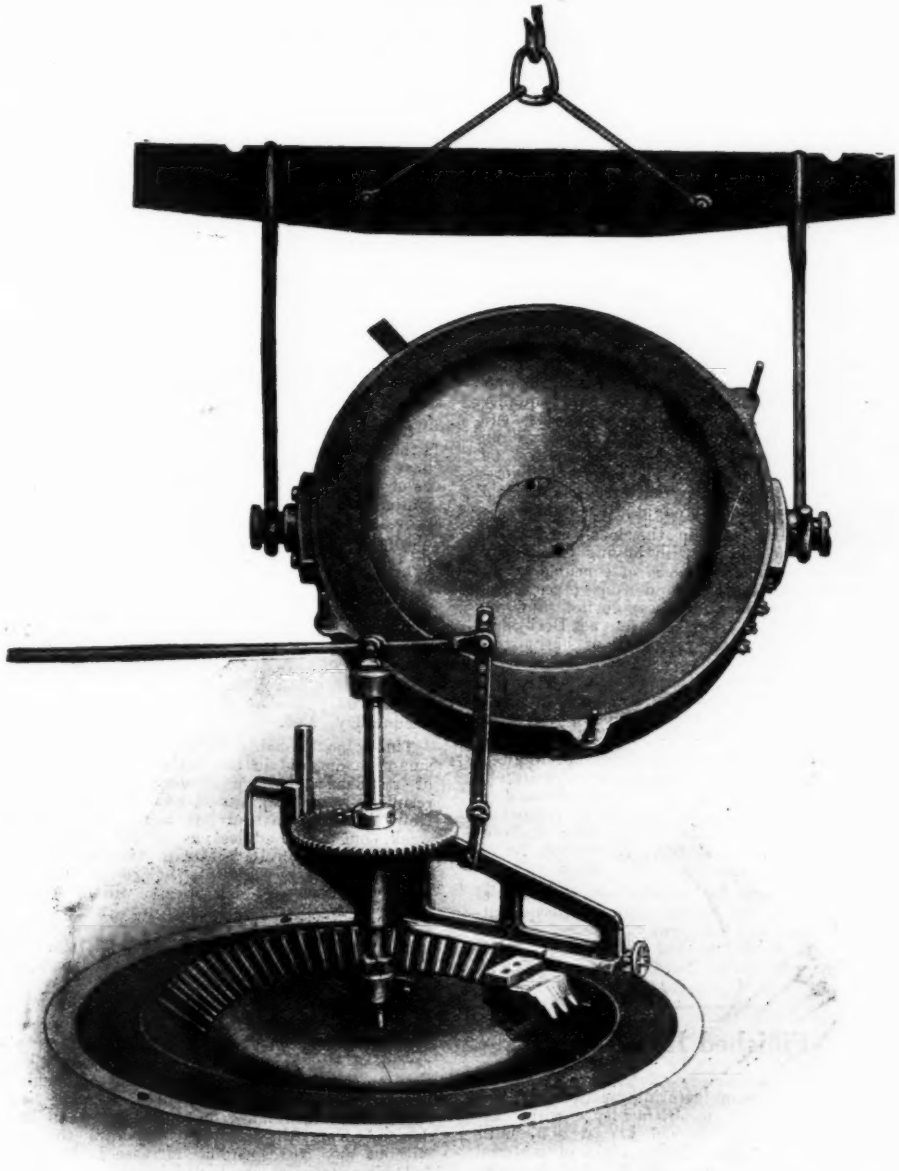
McLEAN, W., founder and director of William McLean, Limited, iron and steel merchants, Campo Lane, Sheffield £39,688

McGRATH, J. M., of Alwyn House, Finchley Lane, Hendon, N.W., for many years principal London representative of W. & T. Avery, Limited £3,704

HODGSON, G. H., of Wyndcliffe, Wilton Road, Ilkley, Yorks, iron and steel merchant, chairman of George Hodgson, Limited, of Leeds, and a director of Jonathan Hattersley & Son, Limited... £132,963

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS,

(MANCHESTER), LIMITED,

BLACKFRIARS, MANCHESTER.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Movements in the Cleveland iron market of late have disclosed few features of interest, with business at the moment quiet and uneventful. In the home trade a fair average business is passing, and users continue to effect moderate forward commitments at current levels. But the export trade is still disappointing. At present Teesside makers are fairly comfortably placed, and the home demand looks like remaining very healthy. The next month or two may witness a distinct change in conditions abroad, which will bring present prices nearer to parity. At this week's market there was no disposition to make further price concessions. No doubt for a really substantial contract 79s. could be broken, but for ordinary business that figure was firmly held for No. 3, No. 1 is 84s., No. 4 foundry 78s., and No. 4 forge 77s. 6d. per ton.

While the outlook in the hematite market on Teesside is distinctly more promising, in view of the better outlook in the steel trade, business just now is comparatively quiet, and values show a somewhat weaker tendency. At this week's market the quotation for East Coast mixed numbers was unchanged at 87s., with 6d. per ton more for the No. 1 quality. This figure could, however, be shaded against substantial business. Prices on the West Coast are unchanged, with Bessemer mixed numbers at 97s. 6d. per ton, c.i.f. Welsh ports, 98s. 6d. per ton delivered at Glasgow, 102s. 6d. per ton delivered at Sheffield, and 106s. 6d. per ton delivered at Birmingham.

LANCASHIRE.—Business in the local market for foundry pig continues quiet, with buying chiefly confined to the more immediate needs of consumers. Up to the present, makers of Midland irons (except perhaps the Northamptonshire furnaces) do not show any anxiety to make sales, and so far as Derbyshire makers are concerned there is plenty of business in hand under the old contracts; so that there is no need to press sales. Hence the price for Derbyshire No. 3 iron remains steady at 90s. delivered in Manchester, and there is no disposition to make concessions in order to obtain business.

THE MIDLANDS.—Although perhaps not quite so firm as last reported, the markets for foundry iron in this area are fairly active, while local demand is well maintained. Ruling quotations are as follows:—Derbyshire No. 3 foundry, 81s. to 82s. 6d.; Staffordshire No. 3 foundry, 83s. to 85s.; Northants. No. 3 foundry, 76s. to 77s.

SCOTLAND.—Demand for foundry iron in the chief consuming centres in the North continues disappointing, and as yet there are few signs of renewed activity to be noted. Prices are inclined to easier levels on the basis of 90s. per ton for No. 3 foundry quality at the furnaces.

Finished Iron.

Conditions in the manufacturing sections of the trade generally remain unsatisfactory, with the notable exception of the marked bar section, mills engaged on the production of this class of material reporting fairly constant employment, with the price consistent at £15 per ton f.o.t. makers' works. This is not the case, however, in respect to the works rolling the crown and nut and bolt irons, which are all on short time, and they experience great difficulty in getting orders. At the price of £12 10s. to £12 15s. for crown iron, the works state, it is impossible to effect any reduction. Bolt iron is quoted locally at £11 15s. delivered, but little support is forthcoming, because the Darlaston bolt makers are very short of work. Iron plates remain at £16 per ton basis delivered this district, and the few makers of this type of plate are moderately busy.

Steel.

At Sheffield recently, business in steel has been somewhat unsettled, with very little doing in billets, either acid or basic, though quotations are very steady. A good volume of business in alloy steel is being transacted, and another strong local feature is the demand for cold-rolled steel strip. Business in railway and motor steel is on a fairly satisfactory scale. The general conditions in the tinplate trade remain unaltered, except that more orders seem to be about than was the case recently. What business has been done has been on the base rate of 23s. 6d. I.C. f.o.b. Bristol Channel ports.

Scrap.

Corresponding to a great extent with the conditions in pig-iron above outlined, the position in the scrap metal trade at the moment may best be described as unsettled, with demand on a curtailed scale, and little sign of renewed activity in the immediate future. In the Lancashire market for cast scrap iron business is still very much restricted, but dealers manage to keep the prices steady, although the iron-founders are buying only sparingly. Generally speaking, good ordinary broken machinery metal is offered here at 85s. per ton, but one would not like to say that in some cases founders are not able to buy at a little less. For broken textile machinery dealers ask 90s. per ton, delivered; but there is only a comparatively small supply in this class of metal. In the Scottish area, machinery cast-iron scrap is rather slow again, and 90s. to 92s. 6d. per ton is being asked, but with few transactions. Ordinary cast-iron scrap, in pieces suitable for foundries, is 85s. to 87s. 6d. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Markets for standard during the past week, although without outstanding features of interest, have maintained generally a fairly steady tone, with values slightly below the previous levels. In the United States business is quiet, but a strong tone prevails and higher prices are being asked by producers for both nearby and future shipment. Business in the outside market is quiet, but a stronger tone has been evident with more interest shown by operators in future positions. Less copper is being offered by second hands, either f.o.b. refinery or for foreign shipment. Current quotations:—*Cash*: Thursday, £64 17s. 6d.; Friday, £65 10s.; Monday, £65 10s.; Tuesday, £65 7s. 6d.; Wednesday, £65.

Three Months: Thursday, £65 17s. 6d.; Friday, £66 12s. 6d.; Monday, £66 10s.; Tuesday, £66 7s. 6d.; Wednesday, £66.

Tin.—Due probably to the recent decline in consumptive demand in the Welsh tinplate trade, values of standard tin have developed a lower tendency, resulting in a total loss of over £8 on the week. In New York the market has again been inactive and weak, but cable advices as to the general situation are encouraging. In the U.S. tinplate industry 460 mills—out of a possible total of 528—are now at work, and the estimate of deliveries of tin in America this month is 7,000 tons. Eastern cables report sales at £261 10s. per ton, c.i.f. London. Current quotations:—*Cash*: Thursday, £257 5s.; Friday, £261 5s.; Monday, £263 5s.; Tuesday, £261 15s.; Wednesday, £263 12s. 6d.

Three Months: Thursday, £260 10s.; Friday, £265; Monday; 267; Tuesday, £265; Wednesday, £266 15s.

Spelter.—The market for this metal has also experienced a setback, and there has been little disposition to buy on forward account. Although a fair demand is still being experienced, supplies have been sufficient to meet all requirements, but an increasing demand from the Continent appears to be likely, without any corresponding increase in supplies. The following statistics are issued by the Metal Exchange: Stocks of spelter: December 31, 396 tons; November 30, 541 tons. Current quotations:—*Ordinary*: Thursday, £37 6s. 3d.; Friday, £37 5s.; Monday, £37 5s.; Tuesday, £37 5s.; Wednesday, £37 7s. 6d.

Lead.—Business in soft foreign pig continues on a moderate scale, with prices inclining to lower figures for all positions. The very high price at which the metal stands might make it the most vulnerable to attack, but there is a general recognition of the real strength of the position. Consumption in certain directions probably has been curtailed, owing to the high prices, but the main demand is for electrical purposes, and there is little chance of this permanently falling off. Current quotations:—*Soft foreign (prompt)*: Thursday, £40 5s.; Friday, £40 2s. 6d.; Monday, £39 17s. 6d.; Tuesday, £39 15s.; Wednesday, £39 5s.

THE CAMPION BLAST METER, which was recently described and illustrated in our columns, is being distributed through the following sole agencies:—Scotland and Ireland, Thomson, Skinner & Hamilton, 137, Sauchiehall Street, Glasgow, C2; North-Eastern Area, H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne; and the rest of England and Wales, The Constructional Engineering Company, Limited, Charles Henry Street, Birmingham. Inquiries should be addressed accordingly.